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## THE SCIENTIFIC STUDY OF RELIGIONS.

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THE general history of religions is taught, if I am not mistaken, only in Leyden, Paris, Tübingen, and Geneva. In giving a place to this new branch, the University of Brussels has again shown its fidelity to the liberal spirit that actuated its founders. Imperfectly qualified as I am to give direction to studies on this subject, I am encouraged to undertake it by the thought that to teach the history of religions, it is not necessary to be acquainted with all the languages of all the peoples who have professed them. I am far from depreciating such knowledge, and readily recognize that the founders of the science of religions have nearly all been trained in special studies of this very kind. But all the branches of the ancient literatures, through the discoveries of those who have so laboriously delved in them, now offer general results sufficiently certain and well developed to enable us, without doing over the work of the specialists, to attempt the synthesis of their conclusions, and relate the history of religions as we do the history of arts, sciences, languages, or peoples.

Henceforth the science of religions will be chiefly a question of method and assimilation. As Professor Tiele stated in 1877, for the Assyrio-Babylonian religion: "The historian, the ethnologist, and the scholar, who devote themselves to the science of comparative religions, have each their several tasks. The domain they occupy can no more be disputed as against them than they can encroach upon that of the epigraphist and the philologist."

It might be asked why, if it is so easy to get positive information on the nature of the different religions, it is not more widely diffused.

It is principally because, aside from a few fugitive notions, often quite obsolete, on the mythology of Greek and Latin antiquity, the history of religions is wholly unprovided for in our courses of instruction; and, secondly, because there prevails a mass of prejudices tending to restrict the application of scientific methods to this study.

Among these prejudices there are some which are always found, although in a less degree, in all the subdivisions of historical science, while others are peculiar to this particular branch. Some of them tend to hinder even the existence of hierography, while others simply falsify its applications or vitiate its conclusions. My object is to point out the most formidable of these prepossessions by exhibiting, through a few examples, the mistakes into which they may cause even the best-intentioned persons to fall.

We will begin with examining some prejudices that are connected with the very object of our study—the religious and the anti-religious prejudice. It should be understood that when I use the word prejudice in this connection, I employ it in its etymological sense of a judgment fixed in advance, and not in the ordinary sense of something offensive. Our purpose is to study religions, not to insult them.

Max Müller has written that there have existed two systems broad enough to tolerate a history of religions—primitive Buddhism and Christianity. He doubtless meant Christianity as he professes it, and as he saw it professed around him—the Christianity of Stanley and Colenso, of Maurice and Martineau, of Kuenen and Tiele, of Reville and Lenormant. He does not hesitate to recognize with what facility one may be led away from the historical method by belief in the possession of a supernatural revelation, when this revelation is formulated by the agency of a man of reputed infallibility, of a church assembled in council, or of a book finished and closed forever: when it pretends to trace around its affirmations a circle impenetrable to free examination, it is wanting in the most essential conditions for passing serious criticism. When the believer's right to interpret the sacred books is acknowledged, a place is left open for exegesis, but that exegesis still remains the slave of particular texts or dogmas that limit and consequently trammel it.

Let us take a single story from the Bible—that of Jonah, and examine the different acceptations it has received. We could hardly find a richer stock of interpretations vitiated by what I call the religious prejudice. According to the rationalist mode of interpretation that flourished in Germany at the beginning of this century, Jonah was an envoy from Israel to Nineveh, who was picked up after having been shipwrecked, three days from the shore, by a ship carrying the image of a whale as its figure-head. Another interpretation is that of Grimm, that the whole history passed off in a dream. This is to save the letter, but at the expense of the spirit. The important matter in the critical study of a text is to find what its authors intended to put in it, and

not what it ought to contain in order to conform to our ideas of truth or of justice. "There have been and still are," said Dean Stanley, relative to these points, in his funeral address on Sir Charles Lyell at Westminster Abbey, "two methods of interpretation which have wholly and justly failed: the one that attempts to distort the real sense of the words of the Bible, to make them speak the language of science; and the one which tries to falsify science, in order to satisfy the supposed exigencies of the Bible." *

We pass next to the symbolic interpretation. There is nothing to prevent our seeing in Jonah the symbol of the soul, and in the whale that of death or the tomb, so that we might reduce it all to an allegorical representation of man's immortality, such as we see among the monuments of the Catacombs. Or, we might imagine, with Professor Herman von der Hardt, that the vessel in the storm is a figure of the Jewish state, its captain of the high-priest Zadok, and Jonah of King Manasseh, taken prisoner by the Babylonians.† I am far from despising the value of this method of reconciling faith with reason, and I have not the courage to blame those who seek thus to save the integrity of their beliefs. But if symbolism permits the accommodation of religious tradition with the progress that has been made in most of the sciences, one branch of knowledge must be excepted from the rule, and that is history, whose mission is to ascertain, not if the old bottles will hold new wine, but what was put into them in the first place.

There is, however, one means of reconciling independence in criticism with belief in the divinely inspired character of a story. It consists in limiting the inspiration to the philosophical and moral truths included in the text, and letting the rest go. Thus, what in the book of Jonah may be of divine origin are the exalted lessons to be drawn from it respecting the prophetic mission of Israel, on the efficacy of repentance for the forgiveness of sins, and on the equality of Jews and Gentiles before God. And there is nothing to prevent our seeing in the incident of the whale and the other fabulous details of a narrative which M. Edouard Reuss calls a moral story, a simple invention to give more force and color to the religious and moral lessons, or perhaps a reminiscence of the mythical adventure attributed by the cuneiform texts to Bel Merodach,‡ and which is found besides in the solar mythologies of the Greeks, the Polynesians, the Algonquins, and the Caffres, and in the oldest version of "Little Red Riding Hood." Instead of losing by this, the book of Jonah becomes, as M. Kuenen

* The defenders of the Bible have not been the only ones to venture in this way. Thus, M. Jules Soury, in his desire to make the cylinders square with the doctrine of evolution, once asserted the entire conformity of the Chaldean creation myths with Darwin's theories of the origin and transformation of species. ("Le Temps," 13th and 23d November, 1879.)

† See the "Book of the Twelve Minor Prophets," by E. Henderson, London, 1845, p. 200.

‡ Professor Sayce, "Chaldean Genesis," vol. iii.

remarks, the book of the Old Testament farthest removed from Jewish particularism, and most nearly approaching to Christian Catholicity; and this should be ample compensation for the sacrifice of its miraculous and supernatural part. M. Francis Lenormant has applied the same method in his studies on the "Origins of History according to the Bible and the Traditions of the Oriental Peoples." "I do not recognize," he writes, "a Christian science and a freethinking science; I admit only one science, the one that has no need of any other epithet, which lays aside theological questions as foreign to its domain, and of which all seekers in good faith are the servitors, whatever may be their religious convictions. That is the science to which I have consecrated my life; and I believe it would be a violation of a holy duty of conscience if, influenced by a preoccupation of another kind, however worthy of respect, I should hesitate to speak sincerely and without ambiguity the truth as I discern it."

It is nevertheless true that hitherto orthodoxies have hardly shown themselves disposed to understand the rights of science in this way.

If religious prejudice opposes itself to the scientific study of one's own religion, can it also interpose an obstacle to the knowledge of strange religions? At first thought we might be tempted to answer in the negative. How can any opinions, even those which we hold as absolute truth, prevent us from observing, classifying, and describing the beliefs, or, if you prefer, the errors of another?

It is a fact that, if we arrange all religious opinions in two categories—that of our own, which we believe came down ready-made from heaven, and that of the religions of others, which we declare indiscriminately to be the results of perversions—we become incapable of grasping the real nature of the religious sentiment, and consequently of its different manifestations. With the Iranians, who personify their supreme being in the great Ahura, the *devas* represent the agents of the bad principles. To the Brahmans, who adored the devas, the *asuras* were the adversaries of gods and men. To the historian of religions, asuras and devas are analogous conceptions, which *a priori* he connects with the normal development of the human mind, and *a posteriori* shows to have been derived from the same religious center, anterior to the separation of the Persians and the Indians, and to the organization of dualism in the Aryan theologies.

How shall we preserve the even mind and the freedom of appreciation essential to all impartial analysis of foreign ideas and customs, if we imagine, like some of the fathers, that they are the work of the evil-one? The Christians of the first centuries had no doubt of the real existence of the pagan divinities, but they regarded them as evil spirits who had turned the worship of men from the only God by a caricature of the true religion. Such is likewise the recent explanation given by Father Huc of the curious resemblances which he dis-

covered between the rites of Buddhist worship and some of the practices of Roman Catholicism.

It would be unjust to award to Christendom the monopoly of intolerance. The Emir Hakem had collected at Cordova a great number of books which had been found in the East among the ruins of paganism. The usurper Al-Mansour had them torn up and burned. Those which escaped this reaction of Mussulman fanaticism perished, three centuries later, with eighty thousand manuscripts that Roman Catholic fanaticism caused to be thrown into the flames of Granada, after the expulsion of the Moors.* Even the Protestants are not free from reproach in this matter. Sir George Mackenzie relates, in his "Travels in Iceland," that the Lutheran clergy used all its power to prevent the first publication of the "Eddas," the ancient epics of Scandinavian mythology.

Greeks and Trojans were not more bitter in their disputes over the body of Patroclus than Protestants and Catholics in wresting honestly the texts of the fathers and the monuments of the Catacombs to deduce from them the justification of their respective views on the questions in controversy between them. What should we expect, then, when the question is one of giving to a rival cult the place which legitimately belongs to it in the development of man? Bishop Huet would find but few imitators in this age of his efforts to discover Moses in the persons of Zoroaster, Orpheus, Apollo, Vulcan, Faunus, Thoth, Adonis, and Tammuz.† But even the best-informed and most sincere apologists allow themselves to exaggerate the antiquity of the Hebrew traditions while looking for the source or the affiliations of the biblical stories.

Thus, we had long known, from fragments of ancient authors, that the Babylonians had a cycle of legends presenting some analogies with the traditions of Genesis. They were generally believed to be an infiltration or a vague echo of the Mosaic account. But in 1872 Mr. George Smith deciphered from a Ninevite tablet an account of the deluge, which was singularly like the Hebrew version in the details of the composition, the course of the narration, and the style. The priority of this document to the first book of the Bible seems established in evidence. Lenormant declares that it must have been composed several centuries before Moses. The Babylonian version illustrates the original signification of the tradition, by showing it to be a myth of a great storm or of the rainy season; while, in the Mosaic version, the naturalistic character almost disappears under the more elevated interpretation, conceived from the moral and monotheistic point of view. We, therefore, seem authorized to conclude that, if the story in Genesis is not derived directly from the Chaldean tradition, the latter

* Ernest Renan, "Averroës et l'Averroïsm," pp. 4, 60.

† But we have recently seen—probably by way of reprisal—M. Jacolliot finding in Moses, as well as in Menes and Minos, the Manu of India.

nevertheless represents a version much nearer to the common source. Yet the contrary opinion prevails among the majority of orthodox students, because they take as their point of departure the necessary infallibility and priority of Genesis.

Sometimes the prejudice is frankly avowed. In January, 1880, the Abbé de Broglie began at the Catholic Institute of Paris a course on the history of non-Christian religions, and the "Polybiblion" of the next month gave the following summary of his opening lecture: "He proposes to show from the history of the most widely spread false cults that they are not to be compared with Christianity, and, coming down from generalities to a more special study, he will make a brilliant demonstration of the superiority of our religion." This is not history, but apologetics.*

We very frequently meet with an inverse kind of apologetics among the adversaries of religious ideas. In fact, the anti-religious prejudice, which rests, like the religious prejudice, on an exclusive view of things, is a direct result of dogmatic intolerance. If one is in the habit of regarding the ideas of others as a heap of superstitions and impostures, it is easy to conceive that, when he loses faith in the supernatural origin of beliefs, he will confound all the religions of the earth and the religious sentiment itself in a contempt that will henceforth recognize no exception.

Some think that to occupy themselves with religions is to waste time; as if religious questions did not figure among the vital questions of our epoch. "When I published the translation of the 'Life of Jesus,' by Strauss," writes Littré,† "the objection was made, from the point of view of the freethinker and revolutionist, that I was undertaking a wholly useless work, and one that was out of date, and that the eighteenth century had performed, better than all the Strausses in the world, all the work of demolition that was needed. Yes, the negative work, but not the positive work. And this is no subtile distinction that stops short of going to the bottom of things. Let us consider the aberrations that haunted the mind of the eighteenth century on the subject of religions. It was impossible for it to comprehend anything of their origin, of the part they played, or of their life. They were, according to some, inventions of crafty men who worked upon popular credulity and thereby gained power and wealth. According to others, nothing could be seen in them but periods of ignorance and superstition which it was impossible sufficiently to de-

* The abbé seems to have recognized this himself, for at the beginning of his third year (1881–'82) on the "History of the Religions of India," he changed the title of his lectures to "Course of Christian Apologetics." What, now, becomes of the compliment addressed by the "Polybiblion" to the Catholic Institute of Paris for having inaugurated a course on "Comparative Religion" before the state, with the resources of the budget at its disposal, organized one at the Collége de France?

† See the review "La Philosophie Positive," vol. xxii, p. 368.

spise or lament. According to others, again, some favor might be granted to Jupiter and Olympus, for whom magnificent temples and beautiful statues had been erected; but the flood of historical indignation must be turned upon the shame of shames, of Christianity and the middle ages. Such aberrations, with all their variations, form a vast network of prejudices which is not yet broken up and which still holds bound in its toils the whole radical party of France."

Some minds, struck by the ills which religions have engendered, are willing to admit the utility and even the necessity of hierography; but they do not pretend to look for anything in the science but arguments, or weapons, with which to contest the various forms of belief around them.

Is there any need of explaining that such can not be the purpose of this course? In saying that I will try to treat religions by the processes of science, I am by implication engaged to make neither an anti-religious polemic nor a religious propaganda. Parties and sects are at liberty to draw all the conclusions they please from science; but science should never stoop to be their instrument or sign.

When, in 1879, the French Senate discussed the scheme for introducing the history of religions into the Collége de France, Edouard de Laboulaye became the spokesman of a prejudice that disputes even the possibility of using historical methods in the study of any religion, saying: "When you believe it is true, everything will seem natural to you. When you believe it is false, everything will seem absurd. How are you going to find a way of teaching impartially?"

Henry Martin replied: "I do not say that the comparative history of religions will be to the profit of intolerant religious ideas that proscribe one another as they proscribe irreligious ideas; but it will surely be to the profit of the idea of that universal religion which lies at the bottom of all religions, and is their essence."

I will go further, and say that the historian of religions need not be at the trouble of asking whether the object of the religious sentiment is real or not, or, in other words, whether the belief in the existence of the Deity is well-founded or illusory.

I would also add that, to write the history of religions, it would be necessary to put one's self at the positivist point of view, provided this phrase is not taken to signify a formal adhesion to the philosophical system of Auguste Comte, who also has come to hierography with a preconceived theory. Here, again, I enter upon a new order of prejudice, the *philosophical prejudice*, or that which involves finding in the facts the confirmation of a doctrine determined upon in advance. Orthodox positivism omits from its scientific classification, experimental psychology, the study of which is indispensable, as Herbert Spencer declares, for obtaining the key to the religious sentiment and its evolutions. When the positivists affirm that man must pass, in his individual and social development, through the theological, metaphysical, and positive

stages, they mistake for successive stages three different aspects of the human mind. And, when they declare that all religions must have traversed *successively* the three phases of fetichism, polytheism, and monotheism, they again sacrifice the facts to the spirit of system. By fetichism, Comte understands the worship of material objects, trees, stones, shells, rivers, mountains, celestial bodies, etc., which the imagination of the primitive man arbitrarily invested with supernatural powers, without, however, seeing in them the work or residence of a spirit. But the numerous observations made in our days on non-civilized peoples tend to establish, as Max Müller, Herbert Spencer, Albert Reville, and many others have superabundantly demonstrated, that fetichism as thus understood is nowhere a primitive religion; that it always accompanies and presupposes belief in spirits lodged in things or wandering in space; that it is unknown among people who are placed at the bottom of the religious scale, and reaches its *maximum* among nations that are relatively advanced.

If by fetichism we understand, with M. Girard de la Rialle, "the tendency to regard all phenomena, all beings, and all the bodies of nature as endowed with wills and feelings like those of man, with only a few differences in intensity and activity" *—which constitutes the religious state defined as Naturism by M. Albert Reville—I am ready to admit that something of the kind may have been the first form of religious practice. But the definition goes no further than that of the orthodox positivists, for it implies a previous distinction of body and mind, and worship is in reality exclusively addressed to the latter. Mr. Frederic Harrison maintains that the official religion of China had preserved the type of primitive fetichism, because in it the sky, the earth, and the heavenly bodies were adored, considered objectively, and not as the residences of immaterial beings. Now, all those who have closely studied the ancient religion of the Chinese Empire tell us that veneration is addressed, not to the material appearances of the phenomena of nature, but to the invisible spirits of which the sky, the earth, and the constellations appear respectively as the inseparable envelope, the sensible manifestation, the vestment, or the body. As to adoration of material objects frankly regarded as such, fetichism is a secondary derivative, and not the first form of the religious sentiment.

Another philosophical prejudice, of a contrary bearing, is the one that represents the historical religions as the feeble echo of a primitive monotheism, qualified by natural religion. It seemed to receive a striking confirmation in the first half of this century, when the most ancient monuments of Eastern thought put off their veils before our dazzled eyes. All that we had known till then of the religions professed among the Hindoos, Persians, and Egyptians, with their monstrous idols, their barbarous practices, and their incoherent and coarse

* "Mythologie Comparée," Paris, 1878, p. 2.

myths, seemed either an ignorant distortion, or a willful disguise of the pure and profound doctrines taught in the earliest ages of the world.

From Germany, where the symbolical school of Creuzer had pretended to find in the ancient fables allegories veiling the treasures of primitive religion, this illusion passed to France and to England, where it still has many adepts.

A more complete and more minute study of the documents in which it was believed the echoes of primitive humanity could be found, has discovered that they contain much chaff mixed with the good grain; that they depict, not a monotheism in its decline, but a monotheism in course of formation; and that they are the product of a long sacerdotal elaboration, not the primary expression of the religious feeling in its contact with Nature.*

Nowhere has the contradiction between the theory of original perfection in religion, and the accumulated conclusions of archæology, ethnography, experimental psychology, general history, and religious science appeared to me more marked than in the recent work of M. de Pressensé on the "Origins," precisely because the writer in it impartially expounded all the facts acquired or legitimately presumed by contemporary science. He shows that the religious sentiment has been exalting and purifying itself since prehistoric times. Does not the logical conclusion from this seem to be that that sentiment began with most imperfect and gross manifestations? But M. de Pressensé, generalizing from the fact that a confused belief in a supreme divinity is met among some savages addicted to the practices of fetichism, concludes that monotheism was the primitive faith of man. "Because man in his extreme degradation," he says, "tried to find the divine idea and attach himself to it, he must necessarily have possessed it primitively in its grandeur." † M. de Pressensé approaches the problem of our moral and religious origins with the preconceived notion of a fall, of a degradation suffered by mankind for having violated the moral law, during a first trial of liberty. He does not see that this explanation explains nothing, and that it leaves intact the question, how mankind could at first have realized the divine idea in its plenitude—except by causing to intervene at the beginning, as M. de Pressensé seems inclined to do, a supernatural revelation, or by holding with the poet—

> "L'homme est un dieu tombé qui se souvient des cieux"
> (Man is a fallen god, who has memories of the sky).

* Mr. Max Müller has done me the honor to quote a passage from my lectures on India, in which I brought out the contrast of the ancient Brahmanic philosophy with the idolatry, almost fetichism, with which the stranger's eyes are struck on his arrival in Hindostan. But by this, I in no way intended to maintain that the vulgar practices of Hindooism were a degradation of the Vedic theology, still less that that represented the original and complete condition of the Hindoo conceptions.

† E. de Pressensé, "Les Origines," Paris, 1883, p. 491.

The mind proceeds from the known to the unknown. This is the highway that leads to science, but on condition that the traveler does not wander from it to launch himself into hasty conclusions. The philosophers of the last century, seeking to explain how primitive man fell under the yoke of positive religions, maintained that they were invented by the priests; some added, and by kings. It is true that priests and governments have used religions too much for personal or political interests. But that is no reason for believing that they invented them.

Good sense teaches that the existence of the priest is posterior to the birth of the religious sentiment. Besides this, nothing is more contrary to the tendencies of contemporary science than to regard man as a lump of dough indefinitely plastic in the hands of legislators and mystagogues. Not only is it henceforth averred that all known peoples have religious faiths, in the sense that they admit the existence of superhuman powers intervening in the destiny of the individual, but I shall also have occasion to show that they all possess—at least in a rudimentary state—the essential elements of worship, prayer, sacrifice, and symbols; and that these elements are clad with analogous forms among the most diverse races, and that, wherever we can trace the course of religious evolution, we see faiths passing through phases, if not identical, coming under general laws. Religions make themselves, and are not invented.

From the fact that some kings and heroes have been deified, a few philosophers have concluded that all the gods were deified men. In this way, according to Evémère, among the ancients, the first chiefs or the first sages, having obtained domination by means of their physical or intellectual superiority, have had a supernatural power attributed to them, and have consequently received divine honors. If we had asked this philosopher whence the first believer derived the idea of the supernatural and divine to apply it to kings and priests, he would have been greatly embarrassed to answer us. Evémère's school, resting upon a tradition that Zeus once reigned in Crete, and on the fact that his tomb is shown there, maintained that the master of Olympus was an ancient Cretan sovereign, deified by his subjects. We know now that Ζεύς πατήρ is found among the Romans, the Hindoos, and the Germans, under the names respectively of Jupiter, Dyaus-Pitar, Zio, or Tyr, and with the general character of Heaven-father, the first form of "father who is in heaven."*

Another school obtained a better conception of the real character of the gods, when it associated them with Nature deified in its phenomena. As early as the sixth century before our era, Theogenes of Rhegium declared that Apollo, Helios, and Hephæstos were fire under different aspects—Hera the air, Poseidon water, Artemis the

* M. J. Darmesteter identifies him also with the Ahura Mazda of the Persians and the Svarogu of the Slavs.

moon, and the rest likewise. This was a current opinion among the Stoics. Cicero makes some philosophers, in his treatise "De Natura Deorum," say that the gods recruited either from among the phenomena that strike the imagination, or from among the natural objects that render services to man.*

These views have been confirmed in our days, not only for the Greek and Roman Pantheon, but also for the gods of all known peoples. Only here again we must take account of other theogonic factors. Among the gods there are some who are certainly men or animals deified. Others are derived exclusively from moral abstractions, such as Virtue, Good Faith, Prudence, Fortune, etc., or from metaphysical speculations, like the supreme Brahm of the Hindoos. It should also be remembered that the gods of Nature tend, among some peoples, to become transformed into gods superior to Nature, so that their primitive significance is at last obscured and lost, as Assur among the Assyrians, Ahura Mazda among the Persians, and Jahveh among the Israelites. It was through the failure to grasp these shades that Dupuis, at the end of the last century, wasted his time and learning in maintaining the astronomical significance of all ancient and modern gods and cults.†

We can easily explain how the personification of the celestial bodies and of natural phenomena has led to the representation of their movements and relations as adventures of heroes or of gods. Antiquity had already penetrated the sense of its most transparent myths. But the interpretation of mythology has found its methods only in our own days.

Otfried Müller regarded myths as local legends that translated into a form of personality some particular features of geography or circumstances of history.

Others with Mr. Max Müller have insisted on the solar signification of myths; they have seen in them a reflection of the impression produced on the imagination of infantile people by the periodical succession of light and darkness, of day and night, of summer and winter. Thus, the labors of Hercules are simply the works of the sun during the twelve months of the year. Œdipus personifies the day-star; son of the Dawn, he kills his father every morning; son of the Night, he marries his mother every evening.

Others still, among them Adalbert Kuhn, have set forth that the mind of primitive men was most manifestly affected by the irregular phenomena of Nature and sudden changes of the atmosphere; by this theory the principal myths dramatized the apparent struggles of the sky and the storm, of the sun and the cloud, of the fire and the dark. Developing this view, M. Darmesteter has shown how among the Hin-

* Cicero, "De Natura Deorum," I, 42; II, 23.

† "Origine de tous les cultes, ou religion universelle," by Dupuis, "Citoyen Français, Paris, the Year III."

doos, Persians, Greeks, Latins, and Germans, the story of the creation corresponds with the picture afforded by the apparent new birth of the world after each storm.*

There are those who have seen in myths simple metaphors conceived by poets and taken seriously by their hearers. Thus, when Pindar represents Excuse as the daughter of Reflection, when Prodicus speaks of Hercules as the butt of two women who personify Pleasure and Virtue, they give those images the sense that we ourselves would attach to them; but the figures are taken in earnest by the masses, and so myth arises from metaphor and parable. With still more probability has some confusion of this kind resulted from changes of language, when the appellations of objects personified in this way have lost their primitive signification, and no longer suggest anything but proper names.

Some postulate besides this *auricular* mythology an *ocular* one, holding that the origin of myths should be sought in uncomprehended or badly interpreted drawings. Coins, cups, and primitive objects of art in which emblems, personages, and real or fancied scenes are represented, have set the imagination at work of strangers who acquired them, and they have tried to explain the figures by extemporized legends. According to M. Clermont-Ganneau, the Chimæra and its legend originated in a composition quite common on the Lycian monuments, in which a lion appeared to be devouring a deer. The two animals, if we should suppose them combined by an inexact or ignorant copyist, might in fact give the idea of a monster formed by an amalgamation of the lion and the deer or goat. So the triple Geryon, slain by Hercules, is found among the Egyptian monuments under the form of three men kneeling before a victorious hero.†

According to Mr. Herbert Spencer, the adventures attributed to the celestial bodies and personified phenomena, to the sun, moon, sky, twilight, etc., originally related to human beings bearing the names of those bodies or phenomena as their heroes. Thus, a person who left a living memory among following generations was called Aurora, because he was born at dawn, or for some other reason. Gradually he became confounded with the dawn, and his adventures were interpreted in the way that the phenomena of the nascent day made most plausible. Then, as the same name may have belonged to several persons of different tribes and times, such a juxtaposition of contradictory stories as we find in most mythologies would inevitably have been brought about.‡

My conclusion is that there is truth in each of these theories, and that they do not all exhaust the matter. The law of intellectual development is one, but its combinations are infinite, and to seek to

* J. Darmesteter, "Les Cosmogonies Aryennes, Essais orientaux," Paris, 1883.

† Ch. Clermont-Ganneau, "Mythologie Iconographique," Paris, 1878, pp. 9–12.

‡ Herbert Spencer, "Sociology," vol. ii, chap. xxiv.

bring all the myths under a single process of formation is to pretend to open all doors with the same key. There is no pass-key in mythology.

We have still stronger reasons for being on our guard against seeing myths in everything. Our century has witnessed numerous attempts to reduce, not only the great religious initiators, Moses, Jesus, and Buddha, to myths, but all the persons who have played a considerable part in the traditions of history, from Lycurgus to Charlemagne. A sportive essay has even been made to show that Napoleon I was a solar hero, and sustained by arguments the force of which is hardly exceeded by their wit.*

Even the knowledge that some students have of a particular religion may become a cause of errors. Every one has not the sure glance and the fullness of information that have permitted Max Müller to study the origin of religions "in the light of the religions of India." Read the captivating work on "The Science of Religions," by a writer to whom the Sanskrit antiquities were a kind of family heritage, M. Émile Burnouf. The author sets out to show that "the center from which have radiated all the great religions of the earth, is the theory of Agni, of which Jesus Christ is the most complete incarnation."† This theory, as it is laid down in the Vedas, is nothing else than the scientific doctrine of the identity of the principle of fire and motion, of life and thought. How does the author fill the gap between the Vedic ages and that of the composition of the gospel of St. John? He supposes that this theory, formulated previously to the dispersion of the Indo-Iranians, was transmitted by the Persians to the Jews in captivity at Babylon, and that Jesus, having received it from the latest prophets, communicated it to his disciples, to be divulged only after the formation of the Church. Is it necessary to stop to show that this is simply a hierographic romance?

To still another category of preconceived ideas, calculated to falsify the results of religious criticism, belong the preferences arising from the isolated study of a single science. Such preferences give rise to a natural predilection for the field of investigations we have chosen, and to a tendency to refer to it all the problems we are called upon to resolve. Now, when a student applies the processes of one science to another, he runs a strong risk of erring on the one side by approaching facts with an insufficient method, and on the other by perceiving only the phase corresponding to his order of habitual preoccupations. I will draw my example from the two sciences which have perhaps rendered the most service to the history of religions—linguistics and anthropology.

* This joke has been renewed by some students of Oxford, who have demonstrated, at length and sagaciously, that Max Müller never existed. (See the magazine "Melusine," July 5, 1884.)

† "La Science des Religions," Paris, 1876, p. 259.

Both assume to make hierography a simple province of their respective empires. Sometimes linguists wish to interdict anthropologists from illustrating by comparison myths that do not belong to the same group of languages; sometimes ethnographists and students of folk-lore accuse linguistics of having reduced mythology to a mirage, and, under the pretext that philologists do not agree in their etymologies, deny that they have contributed to the knowledge of myths, even within the circle of the Indo-European languages.* Let us examine the force of these conflicting pretensions:

The comparative grammar of the Indo-European languages is incontestably not sufficient to interpret the myths of peoples belonging to other ethnic groups, or to explain all the mythology of the Aryan peoples. Where myths occur under a form nearly identical among different races, beginning with the uncivilized people of our own epoch, we have a general fact, the source of which should be sought elsewhere than in the language or the isolated history of a particular race. Every one has heard of were-wolves. An explanation of the origin of lycanthropy has been sought in a supposed Greek pun, resting upon the assonance of λύκος, *wolf*, and λευκὸς, *white*. Tradition may have spoken of personages dressed in white; whence a popular legend that they were transformed into wolves. But anthropology disposes of this theory by telling us that among uncivilized peoples very distant one from another, in Asia, Africa, and America, the power is attributed to some men of transforming themselves into wild or dangerous animals, and explains that such a belief flows naturally from the idea that the savage forms of the mutual relations of man and the animal world.†

It is nevertheless true that philology alone can disengage the original sense of some names and some myths from the confusion of gradual changes and parasitical surcharges. How could we have been able to penetrate the myth of Prometheus, or write the real history of Jupiter, without the study of Sanskrit?‡ Sir John Lubbock attempts to explain the origin and attributes of Mercury, or Hermes, by the usage, widely extended among non-civilized peoples, of paying worship to erect stones. These stones, we observe, mark the respective limits of the tribes, are set up in pastures, point out roads, designate the location of markets and intertribal meeting-places, bear inscriptions, and cover tombs. Hence, Mercury came to be regarded as the patron of shepherds, travelers, merchants, and, sarcastically, of thieves, the

* See, in particular, in the "Athenæum" of August 30, 1884.

† "To those who live in countries where wicked people and witches are supposed constantly to assume the form of wild beasts," says Sir A. C. Lyal, writing of India, "the explanation of lycanthropy by a confusion between λύκος and λευκὸς appears utterly idle."

‡ Even Mr. Andrew Lang, who holds to the possibility of accounting for myths without the aid of philology, had to have recourse to it when he came to the Indo-European myths. (See, in the "Encyclopædia Britannica," vol. xvii, p. 153.)

god of games and letters, and the conductor of souls. "He was the messenger of the gods," Sir John Lubbock adds, "because embassadors met at the frontiers; and of eloquence, for the same reason."*

Unfortunately for this explanation, Kuhn has traced the connection between Hermes or Hermias and the two sons of Saramâ, the messenger of Indra, who brought back cows stolen by the demon of the storm. They, the Sârâmâyau, represented the mythical dogs that guarded the road to the other world and led souls to Yama, the subterranean sun, and king of the infernal regions. Going with the Greeks to the West, one of these personages, named Çarvara, became Cerberus; the other was promoted to be Hermes—personifying the wind or the twilight; and we find in Max Müller that that identification "is one of the guiding threads that have pointed out to science the right road in the labyrinth of the ancient Aryan mythology."

Thus we see how, by this exchange of good offices between linguistics and anthropology, the sciences check and correct, and consequently complement one another, each bringing its contingent to the constantly increasing treasure of our historical knowledge. The sesame of this treasure is, "No exclusiveness, no prejudice."

I have now passed in review the principal forms that have served as the vehicle of the aspirations of the human mind toward the invisible and beyond—from vague adoration of luminous and nourishing force to the highest conception of a God at once spirit, love, and truth —from the worship concerned with ghosts and fetiches to the identification of religion with faith in the moral order of the world. What picture could be presented more varied, more instructive, more capable of attracting those who are occupied at the same time with the modern discoveries of science and the great problems of humanity?

If any are animated with the desire of contending against superstitions (using the word in its etymological sense), they can find no stronger tool than this study with which to sap the foot of clay of all idols.

To those who hold to the religious traditions of their childhood, I believe I have said enough, however much our views may diverge, to reassure their conscience, provided it does not resist the impartial search for truth. At all events, they should meditate on that phrase of Chateaubriand's: "We must not say that Christianity is good because it comes from God, but that it comes from God because it is good." This thesis implies full liberty of examination, comparison, and criticism.

I insist on the importance, were it only from motives of patriotism, of propagating the more exact knowledge of religious facts. The conclusions of history are not alone lessons of truth; they are also lessons of tolerance. The historical study of religions, I repeat, is not being

* "On the Origin of Civilization and Primitive Condition of Man." New York: D. Appleton & Co. 1871. P. 205.

anxious to learn whether this or that cult is true or false, or even whether the religious sentiment rests upon a real or an illusory basis. There, however, is a point of view that wonderfully facilitates the knowledge of religions, while it also seems to comprise the supreme conclusion of their comparative history. It is the thought that, among the "innumerable manifestations of the religious feeling of man, no one possesses the absolute truth, but each one includes a relative truth; that all represent, as the later sages of pagan antiquity had already discerned, imperfect efforts to realize a perfect ideal." Here is a ground on which the enlightened partisans of different religions can shake hands, not only with one another, but also with the pupils of science and the friends of progress.

## POSTAL SAVINGS-BANKS.

By Professor D. B. KING.

IT is generally agreed that a system of savings institutions that would be easily accessible to the people throughout the country, give them absolute security for their small savings, and repay deposits at short notice, would, even if the rate of interest were very low, be a great convenience to many people in every community, and a great encouragement to economy and thrift among working-men and people of small incomes. There are many who think that postal savings-banks similar to those which have been in successful operation in Europe and in the British colonies for a number of years would furnish just the sort of facilities for saving that are needed in this country. Many Americans know something of the working of the postal savings-banks in England, where they have been in operation since 1861.

There are now upward of 7,800 of the post-offices in the United Kingdom open, commonly from nine in the morning until six, and on Saturday until nine, in the evening, for the receipt and repayment of deposits. One shilling is the smallest sum that can be deposited. The Government has, however, recently issued blank forms with spaces for twelve penny postage-stamps, and will receive one of these forms with twelve stamps affixed as a deposit. This plan was suggested by the desire to encourage habits of saving among children, and by the success of penny banks in connection with schools and mechanics' institutes. No one can deposit more than £30 in one year, or have to his credit more than £150, exclusive of interest. When principal and interest together amount to £200, interest ceases until the amount has been reduced below £200. Interest at two and a half per cent is paid, beginning the first of the month following the deposit and stopping

the last of the month preceding the withdrawal, but no interest is paid on any sum that is less than a pound or not a multiple of a pound. The interest is added to the principal on the 31st of December of each year.

The methods used for the receipt and repayment of deposits are simple and take but little of the depositor's time. One is not limited, in making deposits or withdrawals, to the office in the town in which he lives. If at any time he desires to do so, he may make deposits in other offices, provided he does not go beyond the total sum allowed a single depositor; his accounts will all be kept together in London, and he can withdraw his money on short notice at any office. These provisions for deposit and withdrawal are sometimes a great convenience to travelers and laborers who make frequent removals. The absolute secrecy which is "enforced upon all officers connected with the banks" leads many working-men to deposit their savings with the Government, who could not be induced to deposit their money with private or ordinary savings-banks where their employers might find out that they were laying by money.

Good results almost always follow the opening of one of these savings-bank offices. Numbers of men and women, boys and girls, are gradually induced to become depositors; money that would otherwise be spent in needless indulgence is left at interest with the Government, and habits of thrift and economy are formed. From December 31, 1874, to December 31, 1884, the number of depositors increased from 1,668,733 to 3,333,675, and the deposits from £23,157,469 to £44,773,773. Trust funds and the funds of charitable and friendly societies, for which special provision is made, are deposited in considerable amounts, so that a large number of persons are interested in the banks in this way.

Since the era of the great frauds which led to the establishment of the postal savings-banks, the ordinary trustee savings-banks have been more carefully managed and guarded. While their number has decreased from 653 in 1861 to 411 a year ago, their depositors have not decreased, numbering more than a million and a half, nor have the deposits fallen off. The slightly higher rate of interest which they pay and the prominent and influential persons who are sometimes connected with their management have made them quite popular in some communities. The funds are invested in Government securities and the chances for fraud are slight. The limit to the amount which one person may deposit in the postal savings-banks has prevented their interfering seriously with private banking enterprises. The proposition to extend this limit has been strongly and, thus far, successfully opposed, the opposition coming chiefly from private bankers. It is generally conceded that, without interfering with established institutions to any considerable extent, the postal savings-banks in Great Britain and Ireland have furnished the working classes with excel-

lent facilities for saving, and have exerted a most beneficial influence in promoting habits of economy and thrift.

The English colonies, seeing the good results of the system that has been described, have established postal savings-banks of a similar character. A higher rate of interest is paid—commonly four per cent—and larger sums are taken from single depositors. The Canadian system, which went into operation in 1868, did not make rapid progress for a time, on account of the good institutions already in existence and the small number of offices of deposit. Greater progress has been made recently. The deposits in

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| June, | 1880, | amounted to | $3,946,000; |
| " | 1881, | " " | 6,208,000; |
| " | 1882, | " " | 9,474,000; |
| " | 1883, | " " | 11,976,000; |
| " | 1884, | " " | 13,245,000. |

In July, 1884, there were 343 savings-bank offices and 66,682 depositors. Of the depositors, 1,400, having $4,722,000 on deposit, were supposed to be farmers; 7,850, having $1,422,000, mechanics; 4,270, having $724,000, laborers; 12,000, with $2,350,000 deposits, married women; and 10,500, with deposits amounting to $1,275,000, single women. The accounts are all kept at the head office in Ottawa, to which each postmaster makes daily reports, and from which receipts are sent to every depositor for every deposit that he makes. Although the amounts received have in the aggregate been large, the losses through frauds have been very small.

Influenced by the success of the English system of postal savings-banks, the governments on the Continent of Europe have now nearly all made similar provisions for the investment of the surplus earnings of the people. The Italian system of postal savings-banks went into operation February 29, 1876. A year ago all the post-offices, except ten, were open as savings-banks. The interest paid is three and half per cent. In 1883 there were 1,305,743 deposits made, amounting to 105,582,729.55 lire. These savings-bank funds are loaned to provinces, communities, parishes, and their divisions, or are invested in fundable bonds or other securities. In France the proposal to establish postal savings-banks was frequently discussed, but not adopted until March, 1881, although the ordinary savings-banks had for several years been allowed to use the post-offices as places for the receipt and repayment of deposits. On December 31, 1883, there were 77,430,000 francs on deposit in the French postal savings-banks to the credit of 374,970 depositors. The well known success of school savings-banks, which are now or will shortly be established in all the schools of France, and the economical and thrifty habits of the French peasantry, would seem to indicate a demand for good and generally accessible facilities for the secure keeping of savings. The Austrian postal savings-banks were first opened January 12, 1883. Up to December 31,

1884, they had received in all 3,311,333 deposits, amounting to 64,763,350 florins. They are well conducted, and likely to prove very successful. The Belgian system has been in successful operation for more than fifteen years; that of the Netherlands was established some three years ago; while Sweden has just followed her neighbors, Denmark and Norway, in establishing similar institutions.

In 1871 Postmaster-General Creswell recommended the establishment of postal savings depositories in connection with the United States post-offices, and two years later he discussed the subject very fully in his annual report. Several of his successors have renewed his recommendation with great earnestness. Hon. Thomas L. James, after referring to and highly approving of these recommendations, said: "It is my earnest conviction that a system of this description, if adopted, would inure, more than almost any other measure of public importance, to the benefit of the working people of the United States." In 1873 Hon. Horace Maynard brought before Congress a bill to establish a national savings depository, but no action was taken. Since then a number of efforts have been made to induce Congress to enact the necessary legislation. The latest of these efforts was made in 1882, under the leadership of Mr. Lacey, whose report from the Committee on Post-Offices and Post-Roads contains valuable information and suggestions on the subject. The bill which Mr. Lacey introduced, and which has recently been strongly indorsed by the State Charities Aid Association of New York, and other advocates of postal savings-banks, provided that none but money-order offices should receive deposits; that no single deposit should be less than ten cents or more than one hundred dollars; that no one person should deposit more than one hundred dollars within thirty days, or have at any time more than five hundred dollars to his credit; and that interest at two per cent should be paid on all sums over three dollars and multiples of one dollar, beginning the first of the month following the deposit, and stopping the last of the month preceding the withdrawal.

Would such postal savings-banks be more convenient and accessible to the masses of the people than existing institutions and organizations which undertake to safely keep the surplus earnings of the people? Would they furnish better security for deposits and greater encouragement to thrift? Could the Government, without interfering with existing institutions and without loss to itself, carry on this savings-bank business? Would the benefits resulting from properly conducted postal savings-banks be sufficient to justify the necessary extension of the functions of our Government and the increase in the number of our civil servants? These are the chief questions to be considered in deciding whether or not it would be wise for the Government to undertake to keep securely the small savings of the people.

There are in this country a number of institutions and organizations which undertake to persuade poor people to form habits of thrift,

and to so invest portions of their earnings as to make some provision for the future. Mutual benefit societies are among the oldest of these organizations, and are very numerous. Some of them confine their operations mainly to giving temporary relief in time of sickness or misfortune, or on the death of their members; others have become practically co-operative life-insurance companies. The sums annually paid into these organizations are in the aggregate astonishingly large. None of these societies, however, enable their members to accumulate capital, and many of them are very unstable and unreliable. The better class of them is not accessible to the masses of the people.

Co-operative societies for production and distribution are not numerous in this country. Many co-operative enterprises have been started, but most of them have failed. The interest in such enterprises seems to be increasing, but at present they furnish but few of our working-men with opportunities for the investment of their surplus earnings.

Building and loan associations have done excellent service in some parts of the country by encouraging persons of small incomes to save money and to invest it in houses for their families. In some parts of Pennsylvania these associations have been particularly beneficial. Large sections of Philadelphia, and of some of the smaller cities of the State, have been built up by them, and thousands of working-men have been led to save portions of their wages, and enabled to own their homes through their agency. In some parts of the country, however, they have not been so well managed, and poor people have sometimes suffered loss and hardship in consequence. These hardships and losses have created great distrust of these associations in some communities. Excellent as is the service which they do, they do not furnish facilities for saving which are available for all classes of the people, nor, with their liability to careless or dishonest management, do they furnish anything like an absolute security for money. The necessity of making regular payments to them and to the mutual benefit and co-operative insurance societies is sometimes an additional incentive to economy, but in other instances it is productive of inconvenience and hardship.

The ordinary savings-banks have furnished all classes of the people in some parts of the country with good facilities for saving small sums, and have especially encouraged habits of thrift among the poorer classes. In 1882 there were in the entire country 667 savings-banks, the average deposits of which amounted to $1,003,737,087. At that time the New England States and New York together had about eighty-one per cent of the savings-banks, and eighty-three per cent of the savings-bank deposits of the entire country.

The New England States are, on the whole, fairly well supplied with savings-banks, having, on the average, one for every ten thousand of the population. In some of these States the banks are so dis-

tributed as to be easily accessible to most of the people; in others there are many communities which are inconveniently remote from any savings institution. Outside of New England, none of the States are well supplied. Even New York, with its one hundred and twenty-seven banks, contains large sections of populous country in which there is not a single savings-bank. The other States are still worse off. In 1882 there were in the Southern States only nine, and in the Western States, outside of Ohio, Indiana, and California, only twenty-one savings-banks. Pennsylvania, with its great manufacturing and mining industries, employing regularly several hundred thousand laborers, is very badly supplied. A few years ago there were a number of savings-banks doing a large business in various parts of the State. Many of these were loosely or dishonestly managed, and their affairs were wound up, sometimes with loss to depositors or stockholders, or both. There still exist a few old and perfectly sound savings institutions, and there are, besides, many private banking concerns which receive large sums of working-men's earnings, but, on the whole, the lack of facilities for the secure investment of small savings is deplorable.

Where the population is dense and conveniently grouped about a number of centers, as is the case in some parts of New England, the ordinary savings-banks may be made to furnish adequate facilities for the small savings of the people. Most sections of this country are, however, rather sparsely populated, and it would not be possible to maintain a good savings-bank in every small town. Some of the savings-banks have been so well managed and are so strong that it would be hard to find better security than that which they offer. In general, the savings-banks of New England have been well managed. Occasionally there has been bad management, and general financial depression has brought disaster upon some of them. Three out of every eight of the savings-banks of Maine suspended between 1872 and 1879. While the losses to depositors were probably less, as a rule, than those sustained by men who had invested their money in land or other securities, the value of which shrank greatly during those years, still these suspensions greatly impaired the confidence of the people in the stability of savings-banks. New York has some very solid savings institutions. The losses, however, to depositors from the failures of twenty-two savings-banks in that State between 1872 and 1879 amounted to $4,475,061. These losses have led many people to distrust perfectly sound institutions. In some parts of New York, New Jersey, and Pennsylvania great hardship and suffering have been caused by savings-bank failures, and great distrust and discouragement have followed.

None of these organizations or institutions, excellent as they may be, furnish the masses of the people throughout the country with convenient facilities for depositing their savings, nor do they, as a rule,

give anything like an absolute security for the funds intrusted to them. There are, moreover, some large sections of the country in which there are no facilities whatever for the safe-keeping of surplus earnings.

Postal savings-banks could easily be made accessible to all the people. There is in every town a post-office, generally conveniently situated, open all day, and visited by many of the people. All classes are accustomed to intrust their letters, and perhaps their money or property, to it. A depository for savings in this office would certainly be accessible to the whole community. A Government guarantee for the money deposited would furnish the absolute security that is needed to encourage the people to intrust their surplus earnings to such savings depositories.

Whether the Government could conduct such institutions without loss to itself, or injury to private enterprise, or the unsafe enlargement of its functions, is a question in regard to which there is some difference of opinion. Perhaps the greatest difficulty would be that of finding some safe, permanent, and profitable use for the money deposited. Many hold that, if the Government should only guarantee the repayment of deposits without interest, large numbers of the people would gladly place their surplus earnings with it for safe keeping. However this may be, a low rate of interest would add much to the popularity and attractiveness of the arrangement. Two per cent has been suggested as a rate that would be attractive to depositors without interfering much with private banking enterprises, provided the sums taken from individual depositors were not too large. It is estimated that the cost of management might, for the first few years, reach three fourths of one per cent. It would be much more likely to fall considerably below than go above this limit. The problem before the Government, then, would be to safely invest the deposits at two and three fourths per cent.

The European nations which have postal savings-banks, with two or three exceptions, have large national debts, which are not likely to be paid off for centuries to come. The investment of small sums by large numbers of the people in Government securities greatly increases the loyalty of the masses and their interest in governmental affairs. The Government thus borrows at a low rate, and an incidental result of its so doing is to render its citizens more thrifty, independent, self-respecting, and loyal. It is certainly an open question whether the policy of rapidly paying off our national debt, when it could be refunded at so low a rate, is wise. Apart from the necessities of the national banking system, there is a great deal to be said in favor of allowing the principal to remain for an indefinite period when the masses of our laboring-men and poorer classes would gladly take the greater part of the loan at two and three fourths per cent, or perhaps even at a lower rate, and be greatly benefited by so doing. The adoption

of such a policy would not necessarily involve the abandonment of the policy of protection. The removal of a portion of the internal revenue taxation would accomplish the necessary reduction of the income of the Government. Of the $348,519,869.92 receipts of the Government for last year, $195,067,489.76 were from customs, $121,586,000 from internal revenue, and the remainder from other sources. Prominent men of both parties are now vigorously advocating a reduction of the burdens of taxation, and, notwithstanding the battle between the free-traders and the protectionists, the general demand for relief will no doubt lead to the adoption of some measure that will cut off the unnecessary revenue. It is evident that the adoption of such a measure can not be delayed many years.

Besides national securities, State, county, and municipal bonds would be available for investment by the Government. Many doubt the wisdom of investing in these, because such securities have in so many instances proved unsafe. The bonds, however, of a number of the States and cities are now considered, by those who are accustomed to invest large sums of trust funds, very nearly as good as Government bonds. If the Government should offer to loan the deposits at two and three fourths per cent, numbers of States, counties, and cities which now pay a much higher rate would be glad to refund portions of their debts, and, in consideration of the very low rate of interest, would doubtless be willing to so draw the bonds that in case of default the Government would have no difficulty in enforcing payment. It would of course be necessary that the investments be made with the greatest care, and that those who have the making of them should possess the confidence of the people in a high degree. The good results that came from the Freedman's Bank when it was wisely administered, and the deplorable effects of the loose management of its affairs in the later years of its existence, would serve as valuable lessons for the conduct of Government savings-banks.

For many years our post-office management has been rapidly growing more and more efficient. Perhaps at the present time no great business is managed more efficiently and economically. There is every reason to believe that still further improvements will be made. Every one is so directly interested in cheap postage, and in the sure and quick delivery of the mail, that inefficiency or dishonesty in the Post-Office attracts attention more quickly than in any other department of the Government. Our rates of postage are now as low as those of Great Britain, although we are compelled to maintain several times as many offices and miles of mail-routes in proportion to the quantity of mail-matter as the latter country. It is scarcely conceivable that, with so strong a public sentiment in favor of honest and efficient civil service, any Administration for partisan reasons would dare to substitute to any considerable extent dishonest and inefficient men for those whose ability and integrity have been tried and proved. It would be suicidal in any party to pur-

sue such a course in a department of the Government which reaches and interests so much all classes of the people. The popular interest in its being well managed would be greatly increased if large numbers of the people were in the habit of intrusting their small savings to it for safe-keeping. The new duties and responsibilities would make the demand for the appointment of honest and capable officials even greater than it is at present, and would, therefore, promote the cause of civil-service reform. The additions to our civil-service list required by reason of such an addition to the functions of the Government would be comparatively few. The Post-Office Department, by means of money-orders and postal-notes, now transmits large amounts of money from office to office. Postmasters and clerks are, therefore, in the habit of receiving and paying out many small sums of money, of keeping detailed accounts, and of making frequent reports. No very great modification of the machinery now in use would be needed for conducting a system of savings depositories in connection with the money-order offices. Occasionally a little more office-room, and another clerk or two, would be needed, but the additions would be comparatively insignificant. The new business would require the same sort of talent and skill as that needed for the issue and payment of money-orders and postal-notes. We might afford to run the risk of whatever danger may come from such an enlargement of the functions and patronage of the Government if postal savings-banks would really prove a great boon to the masses of our people.

Post-office savings-banks would probably not seriously interfere with private banking institutions unless a very high rate of interest were paid and large sums were taken from single depositors. While occasionally deposits would be withdrawn from the ordinary banks and left with the Government, it would probably happen more frequently that poor people who now have no bank accounts would be induced to save some of their earnings, and would in time become capitalists and patrons of national or private banks. In 1873 Mr. Creswell strongly urged that a system of postal savings depositories would not only strengthen our national finances, by bringing large sums into circulation, but would indirectly afford our monetary and banking institutions "the very relief" of "which they stood in need."

It goes without saying that many American working-men are frugal and save considerable portions of their earnings. Evidences of their economy and thrift are seen in the large numbers of capitalists who began life as laborers, and in the thousands of comfortable working-men's homes which the owners have built or bought with their savings. It is evident, however, that great numbers who might live comfortably, and at the same time save enough to make them independent in sickness or old age, and to give their children a fair start in life, spend all their earnings, and are never far from want. The average American laborer is apt to be too generous and open-handed, spending his hard-

earned wages recklessly for the gratification of his momentary desires or fancies. Such a man is liable to be largely at the mercy of his employers. Although wages may be at starvation-point, he can not take his labor to a better market elsewhere. When times are hard, he and his family are likely to suffer. If the great majority of our working-men could be persuaded to save something, however small the sum, each week, the habits of economy and thrift thus acquired would be a great gain to the nation: pauperism and crime would decrease; the comfort, self-respect, and independence of the people would increase; and there would be fewer interruptions to the business and industries of the country growing out of troubles between laborers and employers, for the laborers would become more steady, trustworthy, and independent, less liable to rush recklessly into strikes, and would be less at the mercy of an unfair employer.

Were a system of postal savings-banks established and well conducted, there is no doubt that large numbers of our laboring classes would soon become depositors of small sums. Many working-men now have great difficulty in keeping securely money which they wish to save; others often spend all their earnings for drink or the gratification of their whims or fancies, when they would not do so if they had some perfectly safe and convenient place to deposit the money where it would bring them a little interest, and the fact of their having it be kept a secret. The masses of the people have the greatest confidence in the Government, and would gladly intrust their small savings to its keeping, provided such a system of savings depositories were devised, with such men in charge of it as would command their confidence. It is a question whether at the present time our Congressmen could do so much for the working-man in any other way as by providing him with this means of helping himself.

## THE REFRACTING TELESCOPE.

By CHARLES P. HOWARD.

THOSE who have looked through a large telescope under favorable atmospheric conditions, at one of those immense cyclones which occasionally break out on the surface of the sun, have derived from what they saw a very good idea of the origin of sunlight. They have seen that the brightest portion of the surface of the sun consists of columns of intensely hot metallic vapors, averaging about three hundred miles in diameter, rising from its interior and glowing with extreme brilliancy, from the presence of clouds formed, probably, of shining particles of carbon precipitated from its vapor as the tops of the columns reach the surface and lose heat by expansion and radia-

tion. (A good idea of such a precipitation is had by observing the particles of water condensed from transparent vapor, in unusually high thunder-heads, where the action is in some respects similar.) Between these ascending columns are seen descending masses of cooler vapors, rendered dark and smoky by relatively cool and opaque particles of carbon, all or most of the other elements being still maintained by the excessively high temperature in the condition of transparent vapor. In the immediate region, however, where the cyclone is raging, these bright ascending columns are drawn out horizontally by the inrushing metallic winds (which often reach a velocity of a thousand miles per hour) into long filaments, pointing in general toward the center of the disturbance, which is always occupied by a huge black cloud of smoke (frequently twenty thousand miles in diameter) rapidly settling back into the interior of the sun. Over and across this great central black cloud are often driven long arms of the shining carbon-clouds, which, when the cyclonic action is very strong, bend round into slowly changing spiral forms, very suggestive of intense action. A striking illusion, invariably connected with this sight, is that the observer seems to be viewing it from a position quite near the scene of the disturbance, whose minute and complicated details are seen with exquisite distinctness.

After witnessing such a spectacle, the observer must have felt great admiration for the men who have devised and successfully constructed an instrument capable of showing in action such enormously energetic forces, the very existence of which would otherwise hardly have been conceived.

But, although the refracting telescope has now been brought to such exquisite perfection, the first ones were exceedingly crude, and it is interesting to trace the gradual development of the telescope from a simple pair of spectacle-glasses, suitably placed one behind the other, into the great refractors of Washington, Vienna, and Pulkowa, which are monuments of optical and mechanical ingenuity.

Spectacles were invented about the year 1300, but it was not until 1608 that a Dutch spectacle-maker, as a pretty experiment, combined two such lenses in a way that made distant objects look nearer. A rumor of this invention reached Galileo, at Venice, in 1609, and interested him so much that, before he had even seen one of them, he reasoned the problem out for himself, and in a few days produced a telescope which made distant objects appear to be only one third as far away as they actually were, by cementing a suitable spectacle-glass in each end of a lead organ-pipe. With this instrument the astonished senators of Venice derived great amusement in spying out ships at sea from the top of the great bell-tower.

So industriously did Galileo follow up his first achievement, that soon he had constructed more than one hundred telescopes of various sizes, one of which made objects look eight times nearer; and, finally,

with great exertion and expense, completed one magnifying thirty diameters, which we now know to be the greatest power possible with the form of lenses that he used, viz., a double-convex lens for the object-glass and a double-concave lens for the eye-piece.

With such crude instruments as these, Galileo made his well-known discoveries, which, coming just when they did, proved of great importance in giving an additional impulse to the then rapidly awakening intellect of Europe.

Soon after the death of Galileo the telescope was further perfected by Huygens, who, in the first place, invented the form of eye-piece which still bears his name, and gives a large, flat field with very sharp definition. Many variations of form, but no improvement in the seeing quality of telescopic eye-pieces, have since been made, so that from this time all improvements in the telescope have been necessarily confined to the object-glass.

Huygens next enlarged the single-lens object-glass to its greatest possible power. His largest telescope had an object-glass five inches in diameter, and a focal length of one hundred and twenty feet; this enormous focal length being absolutely necessary to reduce the blurring effect of the prismatically colored fringes, as well as spherical aberration, to such moderate limits that a magnifying power of upward of two hundred diameters could be employed.

To have watched Huygens at work with this telescope must have been an amusing sight. Its great length precluded the use of a tube, and therefore an assistant was obliged to slide the object-glass up and down a vertical pole, one hundred feet high, by a cord, while Huygens pointed the eye-piece at the object-glass by sighting along a string connecting the two, meanwhile steadying himself by resting his elbows on a two-legged wooden horse. A more difficult and unsatisfactory contrivance to use can hardly be imagined, yet, with this telescope, in 1655, he discovered the rings of Saturn, and one of its satellites.

Newton, about this time, hastily concluded, from experiments of his own, that refraction without prismatic color was out of the question, and that the refracting telescope was incapable of further improvement; he therefore abandoned the study of the refracting telescope, and turned his attention to the construction of reflectors, and thus narrowly escaped making that most important discovery—the achromatic object-glass—which, only two years after his death, actually was made by Dollond, who, in 1757, constructed one two and a half inches in diameter, corrected both for prismatic color and spherical aberration.

From that day the power of the refracting telescope rapidly increased, and up to the present moment has only been limited by the ability of the glass-makers to furnish large pieces of optically perfect glass.

The completely equipped telescope, with its object-glass and mounting, aside from being a triumph of the highest optical and mechanical skill, is certainly the noblest instrument that man has yet constructed, and it is difficult to decide which is the most sublime and elevating to contemplate—the universe, which the telescope enables us to see, measure, weigh, and, combined with the spectroscope, to analyze; or the exquisite mechanism, by means of which light is first originated, then propagated, and finally refracted to an image on the retina of the eye.

We shall, in what follows, briefly consider the latter subject, which will enable us to understand the natural laws that render possible the remarkable degree of perfection and power to which the refracting telescope has been carried, and which also fix a limit to its indefinite improvement.

Light is the sensation produced on the retina of the eye by some *force*, usually emanating from a luminous body, but not always, for the same sensation may also be produced by a current of electricity, or by a quick blow on the ball of the eye.

At the first glance this force, which has such a remarkable effect upon the retina of the eye, seems to be a rather difficult thing to interrogate in a way to make it divulge something of its true nature; and so it really proved, for even Sir Isaac Newton, with all the facts known in his day, and with the splendid work of Huygens on the undulatory theory of light before him, failed to satisfy himself on that point; and, in fact, it required the combined work of Young, Fresnel, and many others, extending over a period of two hundred years, to demonstrate beyond question that the one and only explanation admissible is the undulatory theory first propounded by Huygens.

At the present time, however, it is possible to state with certainty a great deal regarding the true character of this force called *light*.

A revolving mirror, properly combined with one that is stationary, shows that light travels between them through a vacuum with the almost inconceivable velocity of 186,000 miles per second; while other experiments prove that this is also the velocity of light through space from star to star.

The diverse and curious phenomena called diffraction, interference, and dispersion, show that light consists of vibrations or waves in some transmitting medium, and therefore that this medium must fill the whole visible universe.

The phenomenon called polarization of light shows that the motion of each particle of the medium as it vibrates is at right angles to the direction in which the waves are propagated, and, strange to say, that the medium transmitting them has the properties of a solid substance, and not those of a fluid, such as a liquid or a gas. A good idea of this kind of a wave is had by observing the wave propagated along a tightly stretched telegraph-wire when it is struck a smart blow with a

stick. Although many of the properties of the light-waves are also common to all forms of wave-motion, yet others are distinctively due to the waves being of this particular kind. This form of wave, therefore, is to be carefully distinguished from that propagated in a fluid, where there is always a forward and backward motion to the particles. For example, in the familiar case of waves on the surface of water, the particles of water move in circular paths as the waves pass by—that is, each particle moves forward and back exactly as far as it moves up and down. Also in the case of sound-waves, which are waves propagated through a gas, the particles of the air move only forward and back along the line in which the sound-waves are advancing.

The diffraction grating shows that the waves which produce the sensation of light are very minute, and are of every possible length, between the limits of 32,000 to the inch to 64,000 to the inch, measured from crest to crest. This is only one fifth of the total range of wave-lengths that have been measured radiating from the sun, but only those longer than $\frac{1}{32000}$ of an inch, or shorter than $\frac{1}{64000}$ of an inch, ordinarily reach the retina to produce the sensation of light. The diffraction grating also shows that the color of light is due directly to the length of the waves, the longest producing the sensation of red light, the shortest of violet, while ranged in between come the various shades of orange, yellow, green, and blue.

Diagram 1 will perhaps give a better idea of the true size and number of the light-waves than is possible from a mere statement of their length and velocity in figures. It represents in section, magnified five hundred diameters, a series of crests of the longest waves that affect the eye as light, passing through a hole in writing-paper, pricked by an ordinary No. 12 sewing-needle, measuring one seventy-fifth of an inch in diameter. It will be noticed that, although the magnified diameter of the hole appears nearly seven inches across, yet the equally magnified crests of the light-waves are still only just far enough apart to be distinctly separated by the eye. On this scale the pupil of the eye would appear nine feet across, and a very good idea of the number of these particular waves, which enter the eye in a continuous stream whenever it receives the light of a distant object, can be had by considering that, if every one of these light-waves passing through the needle-hole in a single second had been represented on the diagram, one behind the other, they would have formed a band extending in the direction of the arrow to a distance of nearly 100,000,000 miles, and to have shown them all on the diagram would have necessitated the paper being long enough to reach from the earth to beyond the sun!

Having once established the fact that the sensation of light is caused by waves originated in the sun and stars, falling upon and irritating the retina of the eye, it of course follows that space must be

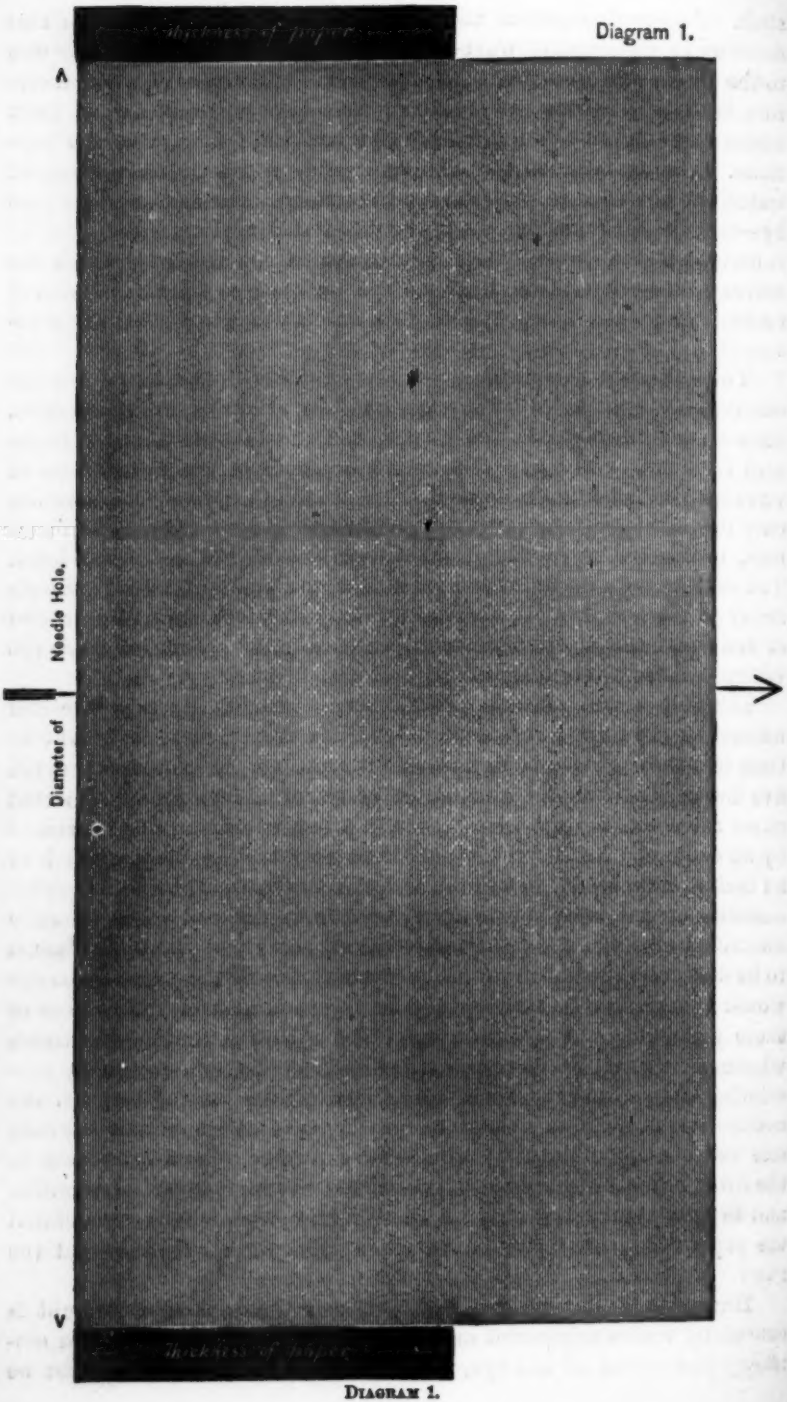


DIAGRAM 1.

filled with some substance having, as we have already seen, the properties of a solid. Now, although it is easier to conceive that all space is filled with some kind of substance than to conceive it to be empty, in order to account for universal gravitation, it is at least unexpected that this substance should turn out to be a solid, yet the polarization of light shows that a solid substance it must be, notwithstanding the fact that the planets rush through it without the smallest apparent resistance.

But even this anomaly is not utterly inconceivable, for many familiar substances have at one and the same time the properties both of a solid and a liquid—for example, pitch, rosin, and tar. We would all probably consider pitch as quite a brittle solid, yet it is at the same time a perfect liquid, as an incident that happened to Alvan Clark will illustrate. He once opened a new barrel of pitch, using a hatchet to crack off some for use in polishing lenses; after breaking off enough for his purpose, he laid the hatchet down on the pitch which nearly filled the barrel, and thought no more about it until some few weeks afterward, when the hatchet could not be found, although he distinctly remembered having left it lying on the opened barrel. He thought it stolen until about two years afterward, when the missing hatchet was discovered at the bottom of the pitch, having sunk into it, clear to the bottom, leaving no hole behind, just as a stone would sink in water, only of course much more slowly.

All who have worked with pitch know that it has the property of being a slowly moving liquid; and it is evident that *this* particular kind of substance at least is a solid to one kind of motion, such as the quick blow of a hatchet, but is a liquid to another kind of motion, such as the steady pressure of a hatchet slowly descending through it. That is, give it plenty of time to flow, and pitch is a perfect liquid; but hurry it, and it is a very brittle solid.

Now, this strange substance which fills all space seems to possess this peculiar double property in a vastly greater degree than does common pitch, for we find that to such a quick motion as a vibrating molecule it acts as a most rigid solid, but to the comparatively slow and steady motion of a planet it acts as an inconceivably thin liquid, allowing the planet to pass through with no apparent resistance.

This remarkable substance, which fills both intermolecular and interstellar space, is called the universal ether. Its properties are only beginning to be learned, and will not probably be well understood until such phenomena as gravitation, electricity, magnetism, and the peculiarities seen in the tails of comets, are satisfactorily explained. A statement, however, of a few of its observed properties is a necessary prelude to a complete understanding of the telescope.

The molecules of ponderable matter are supposed to be inclosed in the ether, just as a wooden ball could be incased in the center of a large block of jelly. The waves of light are supposed to be originated

by the vibration of the molecules, in somewhat the same way as the jelly might be agitated: by vibrating the wooden ball in its center, each molecule as it swings sends an impulse or vibration through the ether, which, traveling with equal velocity in all directions, forms as a whole an expanding spherical wave-front, in shape like a quickly blown soap-bubble, having the vibrating molecule at its center.

The molecules of a hot body are in a state of intense vibration, and, each being suspended in the substance of the ether, originate in it a steady succession of these spherical wave-fronts, which, by one of the fundamental principles of wave-motion in an elastic medium, do not interfere with each other in the least, but each set of waves goes straight on, as if every one of the other sets were not in existence.

When light passes through a transparent substance, such as glass or water, it is propagated, not by the vibration of the molecules of the substance, but by the vibration of the ether in which the molecules are as it were submerged. This is proved by the enormous velocity with which the vibrations are propagated within the substance, which is immeasurably greater than the elasticity of the substance can account for. There are also other phenomena which lead to the same conclusion, but which it is not necessary to allude to here.

It has been found by direct measurement that the velocity of the light-waves is less through transparent bodies than through space. For some reason, the ether acts as if it were heavier within the body than outside of it, being apparently condensed by the presence of the molecules; and the velocity of the waves is lessened by their passage between the molecules of the transparent body, so as to produce an effect similar to that produced on the velocity of waves on the surface of water by the nearness of the bottom, where their velocity diminishes rapidly as the water grows shallower.

Upon this simple fact, that the light-waves progress with less velocity through transparent solid bodies than through space or air, depends the complete explanation of the telescope.

But, before considering the effect of this retardation of the light-waves by their passage through transparent bodies, it is well to get a definite idea of a wave-motion by observing one that is visible to the eye. This can be beautifully done by the elliptical tank of mercury roughly shown in Diagram 2—the velocity of waves on the surface of mercury being slow enough to be easily followed by the eye.

The rim of the dish is elliptical; the little ball to originate the waves is constrained to vibrate at one focus of the ellipse, and it will be observed that each time the ball makes a vibration a circular wave-front, convex toward the direction of its motion, spreads out on the surface of the mercury from the ball as a center, until, meeting the elliptical wall of the dish, it is changed by reflection to a circular concave wave-front, which converges to its center, where the agitation of the surface is much greater than anywhere else; and, indeed, if the mer-

cury were perfectly elastic, as is the ether, the agitation at the center of the completely circular concave wave-fronts would be as great as at the origin of the disturbance.

We also see, from this experiment, that circular wave-fronts travel in a direction at right angles to the direction of their fronts, so that, if

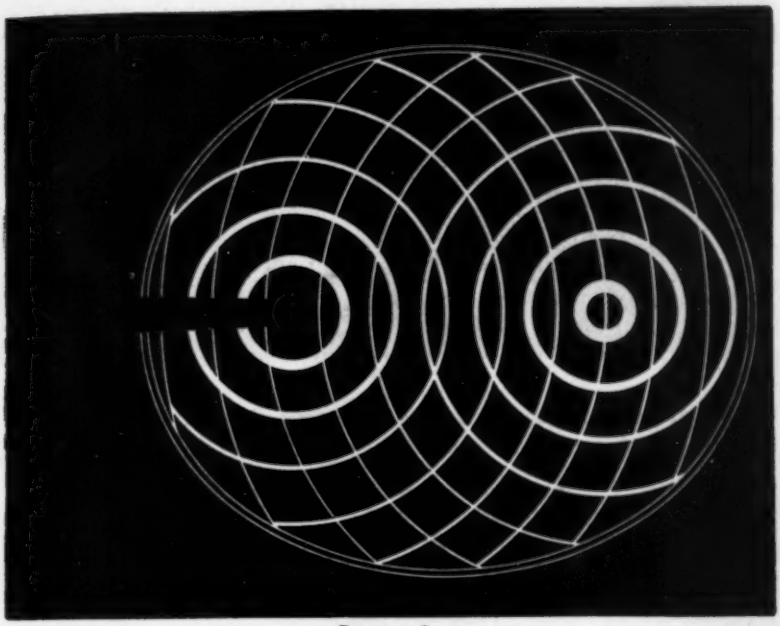

DIAGRAM 2.

from any cause a wave-front becomes circular and concave toward the direction in which it is moving, it will run to a perfect center or focus, and at that particular place create a comparatively great disturbance. By locating the vibrating ball at random on the surface of the mercury, it will also be seen that, unless the concave wave-fronts are truly circular, they will not run to a single point of great agitation, but only a confusion of cross-waves will result.

The same phenomena of wave-motion made apparent to the eye on the surface of the mercury are also true of light-waves: if from any cause the wave-fronts become spherical, and at the same time concave, toward the direction in which they are moving, they will also run to a center, and cause intense agitation at that particular point, but nowhere else.

Diagram 3 represents the effect produced upon the light-waves diverging with uniform velocity and spherical fronts, from a vibrating molecule, by passing through a transparent body, whose faces are surfaces of revolution elliptical in section, called a lens. As already stated, the light-waves are retarded during their passage through the body, and

it is plain that the central portion of each wave-front will be retarded more than the marginal part, having a greater thickness to pass through, so that the central part will lag back; and, when the wave-front emerges, its form will have become concave, instead of convex; and as, with the

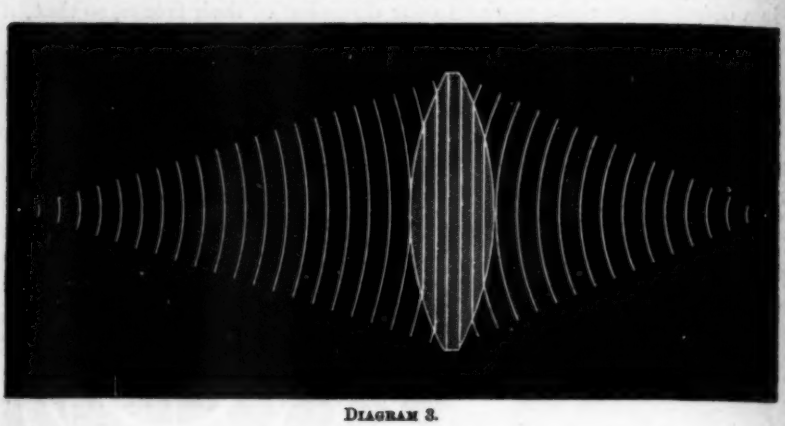

DIAGRAM 3.

particular form of lens that we have assumed used, its form will be spherical, each wave will run to a center or focus, and create there a great agitation.

Now, the same thing exactly will happen if the vibrating molecule is removed to an indefinitely great distance, as for instance to one of the stars: in this case the wave-fronts will be sensibly plane, on account of the distance of the center of curvature, just as the surface of water standing in a pail is sensibly plane, although the center of its curvature is only four thousand miles distant.

It is found experimentally, or it can be demonstrated mathematically, that the vibrating molecule, the center of the lens, and the focus of the emerging concave wave-fronts, lie in a straight line; with this fact distinctly in mind, it is clear that a second vibrating molecule, say, situated in another star, in nearly the same direction from the earth as the first, will also form a second center of agitation or focus, exactly behind the center of the lens, as viewed from that star; and so on from any number of vibrating molecules, each and every one producing a different center of agitation, exactly behind the center of the lens as viewed from them, of course within reasonable limits on each side of the direction of the axis of the lens.

We are now in a position to understand clearly the reason why we are able to see distinctly the forms of distant objects.

Diagram 4 represents the lens of the eye, with plane wave-fronts of light, from two different vibrating molecules, situated in different stars, entering it, and running to a focus or center of intense vibration behind it. The short lines at the back of the eye represent the so-called rods of the retina; when one only of these rods receives

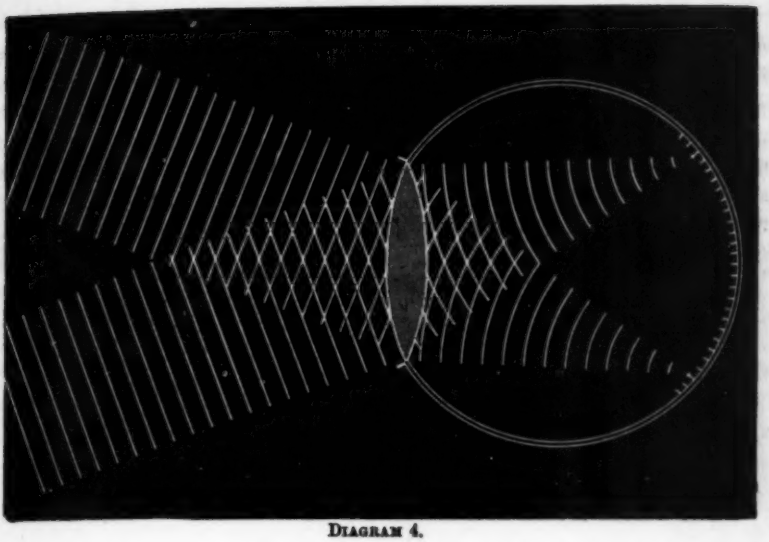

DIAGRAM 4.

a shock, the sensation of a point of light is produced. As shown in the diagram, just one rod is agitated by each set of waves, so that the eye sees in this case two distinct points of light, the brilliancy of each depending upon the intensity of the agitation. A third vibrating molecule in another star would be seen by the eye in the same way, and so on indefinitely.

As the color of light depends merely on the wave-length, we can now understand how the eye sees the constellations in their true configurations and colors; and, as reflected light has the same effect on the eye as that coming directly from self-luminous points, it is plain that the eye must see the form and color of all luminous objects, each individual point of each object forming its own focus on one of these sensitive rods of the retina.

Can any mechanism be more simple and beautiful than that of vision? The more it is studied the more admirable it seems, and we are in a still better position to appreciate the elegance of the mechanism which enables the lens of the eye to form a perfect image of distant objects upon the sensitive retina, when we take into consideration the fact that, were the waves of light not so excessively minute, distinct vision would be utterly impossible.

It is only because the light-waves are so much smaller than the aperture of any lens, such as the lens of the eye, that they run to a focal point, instead of spreading out in all directions, as do the waves of sound which enable us to hear round a corner. The effect of decreasing the aperture of the lens of the eye to a size comparable with that of the light-waves (which would in effect be the same as increasing the length of the light-waves to a size comparable with that of the eye) can easily be shown thus:

The first diagram exhibits the comparative size of a hole one seventy-fifth of an inch in diameter, and the longest light-waves. If we limit the aperture of the eye to this size, by holding a sheet of writing-paper before it, with such a needle-hole pricked in it, and look through the hole at a luminous point, such as a distant electric light, instead of seeing it as a point of light too small to have a visible surface, as we should expect, we will see instead quite a large disk of light surrounded by one or two bright rings as illustrated in Diagram 5.

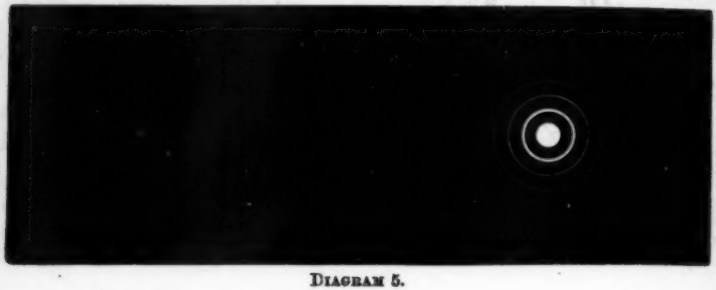

DIAGRAM 5.

This peculiar appearance is caused by the spreading of the light-waves, after passing through the needle-hole, so that, although the wave-fronts are spherical as they emerge from the lens of the eye, yet at the distance of the retina they have spread out sidewise so much that, instead of running to a point, they cover a surface large enough to be distinctly perceived as a luminous disk. It can be proved mathematically by the theory of undulations, that the diameter of this luminous disk, measured in seconds of arc as viewed from the center of any lens, for light-waves, having a length of about $\frac{1}{50000}$ of an inch (the brightest and central part of the normal spectrum), will equal four and a half divided by the number of inches in the clear aperture of the lens, its size, however, increasing or diminishing a very little, according as the light-waves are longer or shorter.

Objects viewed through such a small hole appear very indistinct, from the image of each point overlapping those of its neighbors. The same defective vision would have resulted had the light-waves been created less minute than they are, or of a size comparable to the diameter of the pupil of the eye.

It is also on account of the extreme minuteness of these waves that light appears to travel in rays, and that opaque bodies throw sharply defined shadows.

Returning to a simple lens of considerable diameter, as shown in Diagram 6, and still assuming it to have spheroidal surfaces so that the emerging wave-fronts shall be spherical, and considering the light-waves to be originated by a single vibrating molecule situated at an infinite distance, we come to a peculiar phenomenon, also a result of the excessive minuteness of the light-waves, and the consequent tend-

ency of light to move in straight rays. After the emerging waves have run to a focus, they diverge again from this focus as a new center, with spherical fronts, and in exactly the opposite direction to that from which they arrived, just as if the light emerging from all parts of the lens was propagated through and beyond the focus in straight lines; hence the marginal portion of the converging and diverging wave-fronts on each side of the focus will form two cones, turned in diametrically opposite directions, their common apex being the common center of the spherical wave-fronts, viz., the focus of the lens.

It is now evidently a simple matter to place a second lens at such a distance behind the focus of the first lens that it will transform the spherical wave-fronts diverging from this focus into plane wave-fronts, parallel to those entering the first lens; and, because these waves emerging from the second lens have plane fronts, they must, if they are allowed to enter the eye, come to a focus on the retina, and cause the eye to see a point of light, for precisely the same reason that it would see that point if the two lenses were removed, and the direct light from the vibrating molecule were allowed to enter it.

This is the principle of the refracting telescope; the first lens represents the object-glass, and the second lens the eye-piece.

The Diagram 6 represents the object-glass, the eye-piece, and the eye, in their proper relative positions; also the light-waves from an in-

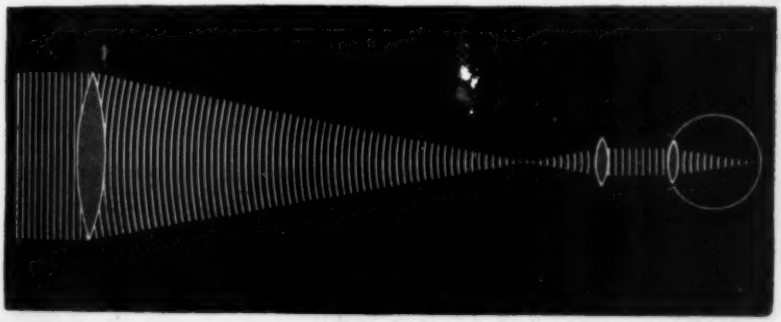

DIAGRAM 6.

finitely distant vibrating molecule entering the object-glass, emerging from it with spherical wave-fronts, which converge to a point of great agitation or focus, whence they diverge with spherical fronts, until, by passing through the eye-piece, they are converted into plane wave-fronts; thence, entering the eye, they come to a focus on the retina.

The diameter of the pupil of the eye being one fifth of an inch, the eye-piece must be of such a focal length that it can be placed so near the focus of the object-glass that the diameter of the emerging cylinder of plane wave-fronts shall not exceed one fifth of an inch, else the cylinder of light entering the object-glass will not be reduced in

diameter by its passage through the object-glass and eye-piece to a cylinder of light small enough entirely to enter the eye.

When, however, this condition is fulfilled, it is clear that, when the eye receives the light from a luminous point through such a telescope, that point must appear as much brighter than it would if viewed directly, with the telescope out of the way, as the area of the object-glass exceeds the area of the pupil of the eye.

Bearing in mind the properties of similar triangles, it is also plain from Diagram 6 that the diameter of the cylinder of light-waves emerging from the eye-piece is as much less than the diameter of the cylinder of light-waves entering the object-glass as the focal length of the eye-piece is less than the focal length of the object-glass. As the focal lengths of object-glasses never vary much from thirteen times their diameter, the focal length of the eye-piece must be thirteen times the diameter of the emerging cylinder of light-waves, which, as just stated, should never exceed in diameter that of the pupil of the eye. Hence the focal length of the eye-piece should never exceed thirteen times one fifth of an inch, or about two and a half inches. This is the greatest focal length which an eye-piece can have to utilize the whole aperture of such an object-glass; to use an eye-piece of greater focal length admits to the eye light only from the central part of the object-glass, and stars appear fainter through it than they do through an eye-piece whose focal length is equal to, or less than, two and a half inches.

As already stated, the vibrating molecule, the center of the lens, and the focus of the converging spherical wave-fronts emerging from it, lie in a straight line.

Diagram 7 represents, with center lines only, to avoid confusion,

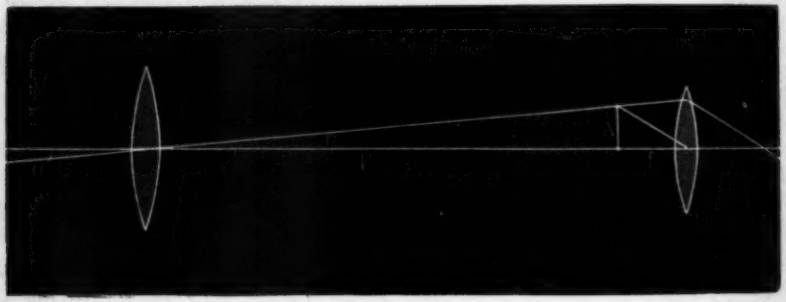

DIAGRAM 7.

the light from an infinitely distant vibrating molecule, situated at an angular distance $\alpha$ from the direction of the axis of the telescope, passing through the object-glass and eye-piece. On emerging from the eye-piece the light will be traveling in a direction whose inclination to the axis of the telescope is equal to the angle $\beta$.

The actual angular distance of the luminous point from the axis of

the telescope is $\alpha$, but it will appear to an eye looking into the eye-piece to lie at an angular distance $\beta$ from the axis. The magnifying power of the telescope is therefore equal to the angle $\beta$ divided by the angle $\alpha$.

The distance $A$ of the focus of the converging waves from the axis is very small, and will equal zero when the luminous point is on the axis, when $F$ will equal the focal length of the object-glass and $f$ of the eye-piece. Extremely small angles being proportional to their tangents, the diagram shows the following expression to be true:

$$\text{Magnifying power of telescope} = \frac{\beta}{\alpha} = \frac{tan.\ \beta}{tan.\ \alpha} = \frac{\frac{A}{f}}{\frac{A}{F}} = \frac{F}{f}, \quad \text{proving}$$

that the magnifying power of a telescope equals the focal length of its object-glass divided by the focal length of its eye-piece.

We have just seen, by similar triangles in Diagram 6, that the focal lengths of the object-glass and eye-piece are proportional to the diameters of the cylinders of plane wave-fronts entering the object-glass and emerging from the eye-piece; it follows, therefore, that the magnifying power of a telescope equals the diameter of the entering cylinder of light divided by the diameter of the emerging cylinder of light.

The easiest way to measure the magnifying power of a telescope is to divide the diameter of the clear aperture of the object-glass by the diameter of the little circle of light seen in the center of the eye-piece when the telescope is pointed at the bright sky, it being assumed that it is in focus for an infinitely distant object. This small circle of light seen in the center of the eye-piece is really an image of the object-glass formed by the eye-piece; but, when the light-waves emerge with plane fronts, the size of this image is exactly equal to the size of the emerging cylinder of plane wave-fronts, so that this method of finding the magnifying power is strictly accurate.

We have seen that, with an eye-piece not exceeding two and a half inches in focal length, luminous points appear through the telescope as many times brighter than they do to the naked eye as the area of the object-glass exceeds the area of the pupil of the eye; and it also follows directly from what has been already stated that, with this eye-piece, the apparent angular distance between two luminous points is proportional to the focal length of the object-glass used. A curious thing following from this is, that surfaces having sensible areas appear no brighter through large telescopes than they do to the naked eye; and it can be stated generally that, using a two-and-a-half-inch eye-piece, which gives the brightest image of an object with any sized object-glass, the surface will appear equally bright, whether seen by the naked eye or through a telescope of any size. The apparent dimensions of the surface, however, will increase directly with the dimen-

sions of the object-glass. This explains why large and faintly luminous surfaces, like comets' tails and the aurora borealis, can be seen no better, if as well, through a telescope than by the naked eye.

We have seen why with any object-glass a lower power than that due to a two-and-a-half-inch eye-piece can not be used without loss of light, and a corresponding decrease in the apparent brightness of luminous points seen through it. We will next consider the reasons which prevent, with a given object-glass, an indefinite increase of magnifying power, and, in fact, confine it to within quite moderate limits. We have all seen beautiful engravings showing as well as it is possible the best views ever obtained of objects like Saturn, Mars, the surface of the Moon, and solar cyclones as they appear through some of the great telescopes, and it must naturally occur to many to ask why a still higher magnifying power than those used can not be employed to make such objects appear still larger and more distinct, for it is certainly easy enough to make eye-pieces of shorter focal length than those used in making the engravings just referred to, which, with a given object-glass, is the only thing upon which the magnifying power depends.

When the focal length of the eye-piece becomes reduced to one sixth of an inch, the diameter of the cylinder of light-waves entering the eye can only be about one thirteenth of this, or less than one seventy-fifth of an inch, as is obvious from Diagram 6, and the eye now becomes sensible of the same blurring effect that was found to occur in looking through the needle-hole; and, if a brilliant object too small to have visible dimensions is observed through the telescope with such an eye-piece, it will appear as a disk of considerable size surrounded by one or two bright rings.

These are the diffraction disk and rings, always seen in viewing a star through a good telescope with a high magnifying power. The disk is brightest at the center, diminishing somewhat in intensity toward the edges, for which reason the diffraction disks of faint stars appear slightly smaller than do those of bright stars.

Their appearance is not simply due to the smallness of the cylinder of light entering the eye through the eye-piece, but it must be remembered that it is the diffraction disk and rings at the focus of the object-glass which are viewed through the eye-piece, and not an absolute point of light. The effect of this, however, can not ordinarily be distinguished in the appearance of a star, so that in practice it is found that the apparent diameter of the diffraction disk of a star, expressed in seconds of arc, equals about four and a half divided by the number of inches in the diameter of the clear aperture of the object-glass.

The diffraction disk becomes very important in observing close double stars. It is obvious that, unless the two diffraction disks of the component stars can be clearly separated, the star can not be seen to be double; to accomplish which the distance between the centers of the stars must at least equal the diameter of the diffraction disks.

In other words, the closest double star which a telescope will separate, expressed in seconds of arc, equals four and a half divided by the diameter of the aperture of the object-glass in inches.

A 4½-inch object-glass will separate the components of a double star when they are within one second of each other; a 9-inch object-glass when within half a second of each other, and a 30-inch object-glass when within about one seventh of a second of each other.

Diagram 8 shows the advantage of increasing the aperture of the

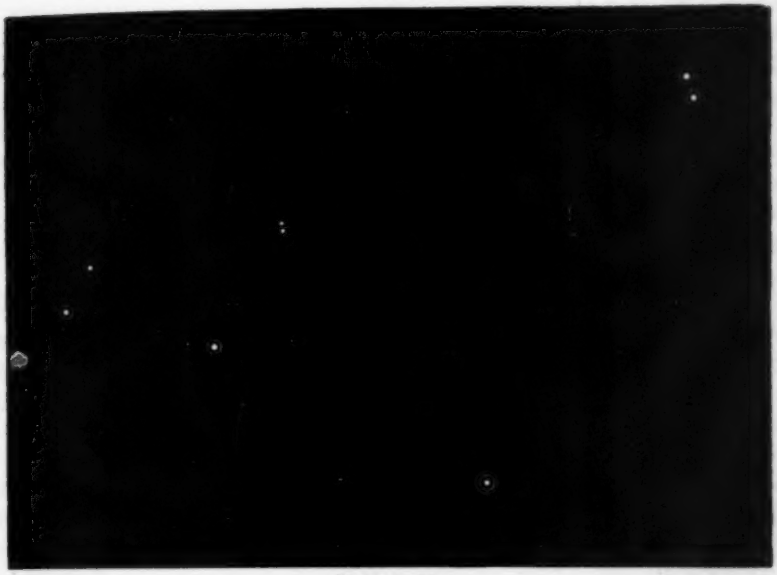

DIAGRAM 8.

object-glass; it represents the triple star $\gamma$ Andromedæ as seen through a 4½-inch, 9-inch, and 30-inch object-glass, in all cases with a one-sixth-of-an-inch eye-piece, which makes the diffraction disks plainly visible, and in every case of the same apparent size but of a brilliancy proportionate to the area of the corresponding object-glass. Through the 4½-inch the upper star can not be separated into two, through the 9-inch, however, both components are distinctly visible, while through the 30-inch they appear widely separated.

If the one-sixth-of-an-inch eye-piece were replaced by another whose focal length was only one twelfth of an inch, the apparent distance between the centers of the stars would of course be twice as great, but the diameter of the diffraction disks would also be twice as large, and therefore have but one fourth their former brightness, and the close double star, instead of being seen to better advantage, would merely appear as two larger and much fainter disks than before, and could not be divided so well.

A very good way to see the effect of using a power high enough

to make the diffraction disks obtrusively large is to point the telescope at a rough stone building in very strong sunlight. The small crystalline surfaces in the stone reflect the sun in little shining points of light, which, observed through the telescope, make the building appear as if stuck all over with silver dollars, while an unnatural glassy blurring of the whole image is very apparent. If the illumination will bear it, this appearance can be greatly exaggerated by covering the object-glass with a pasteboard diaphragm in such a manner as to considerably reduce its clear aperture.

For exactly the same reason, a similar blurred appearance is disagreeably noticeable when objects like the Moon or Jupiter are observed with an extremely high power.

From what has just been said, it is obvious that a power higher than that due to a one-sixth-of-an-inch eye-piece is of very little use in connection with an object-glass whose focal length is about thirteen times its clear aperture; but, had the waves of light been created more minute than they are, it would have been possible to employ with advantage a still higher power.

It is thus seen that the focal lengths of telescopic eye-pieces, no matter what the size of the object-glass may be, should all lie between the very narrow limits of two and a half inches for the lowest power and one sixth of an inch for the highest power; six or seven of them give a sufficient range of magnifying power to fully utilize the object-glass of any telescope.

A convenient way of expressing the limiting magnifying powers of a telescope in terms of the size of its object-glass, independently of its ratio of aperture to focal length, is easily deduced from the above by a simple proportion, and is as follows: a telescope will not bear with advantage a lower magnifying power than five nor a higher magnifying power than seventy-five for every inch of clear aperture of its object-glass.

In all that has gone before, we have confined ourselves to the consideration of the single set of light-waves originated by a single vibrating molecule, and to single-convex lenses, having surfaces of the proper curvature, to convert the convex spherical or plane wave-fronts into concave spherical wave-fronts; but how is it in reality?

We have seen that the light of the sun originates in clouds of precipitated carbon from the great upward currents of metallic vapors rising from its interior. It can be demonstrated that the molecules of water are so small that, were one drop enlarged to the size of the earth, the individual molecule would only come up to the size of horse-chestnuts. There is no reason to think that carbon-molecules differ greatly from this in size. Therefore we receive from the sun the enormous number of light-waves originated by each vibrating molecule, suspended through a depth of many miles in the transparent vapors at the surface of a globe 885,000 miles in diameter. These light-waves

reach us of every possible length between the limits already referred to, and vibrating in every possible plane, so that, even if our lens would make the wave-fronts emerge spherical, it would be found that the long red waves would come to a focus considerably farther out than would the short violet waves, and confusion of the image and colored fringes would result. It is also found impossible to construct lenses with surfaces of any other shape than spherical; consequently the optician has quite a complicated problem to solve before he can construct an object-glass which will not only make the wave-fronts emerge strictly spherical, but which will also make the red, green, and violet waves unite at the same focus, and thus cause all the waves from each luminous point like a star, which is a sun, like ours, too distant to have visible dimensions, to agitate but a single rod of the retina.

In practice, this is almost perfectly accomplished by combining a convex lens of crown-glass (the optical name for plate-glass) with a concave lens of flint-glass (the kind used for the finest cut-glass for table-ware), placed close together; but, to arrive at this result when the lenses are of large aperture, requires an amount of skill and patience attained by few.

Diagram 9 shows the two most approved forms of object-glasses.

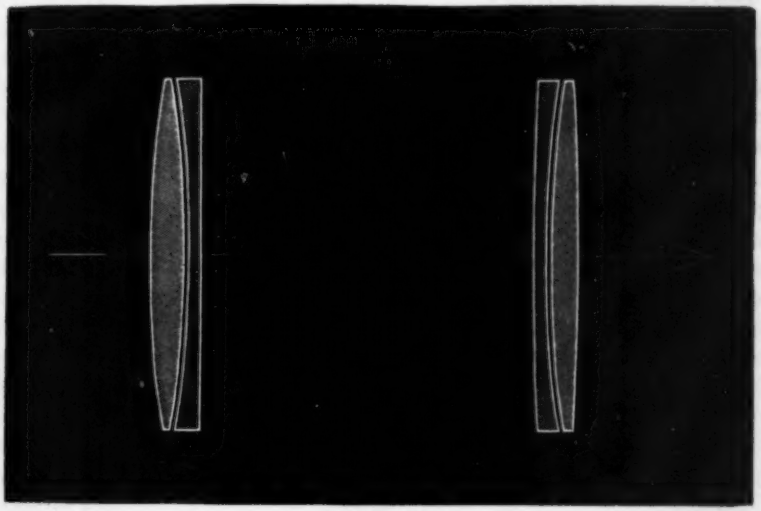

DIAGRAM 9.

The first is that used by Alvan Clark, in the largest and most perfect telescopes ever constructed. It consists of a double-convex lens of crown-glass, combined with a plano-concave lens of flint-glass, the crown-glass lens being placed in front. Both surfaces of the crown-glass lens and the first surface of the flint-glass lens have the same curvature. The focal length of this object-glass is nearly equal to

four times the common radius of curvature of the three surfaces just mentioned.

The second is that derived by Dr. Charles S. Hastings from an elaborate mathematical investigation of every possible form of telescopic object-glass. In this form, on the contrary, the concave flint-glass lens is placed in front of the convex crown-glass lens, and close to it. The two inner surfaces have nearly the same curvature; the two outer surfaces, though not quite alike, have a curvature whose radius differs but little from three and a half times that of the inner surfaces. The focal length of this object-glass is about four times the radius of curvature of the inner surfaces. This form of object-glass gives the sharpest definition attainable with the use of only two kinds of glass whose surfaces are of reasonably small curvature.

## THOMASVILLE AS A WINTER RESORT.

By E. L. YOUMANS.

AS the winter season approaches in the Northern States and in Canada, with its dangers to many and its discomforts to all, the question will be often asked, "Where shall we go to secure the best advantages of a milder climate?" The obvious, and with many the sufficient, answer will be, "Go South, where it is warmer." This may be satisfactory for the numerous and increasing class of well-to-do, leisurely, and healthy people who seek a change of climate purely as a matter of personal enjoyment. They are simply in quest of pleasurable sensation, and their instincts may be trusted to find the nicest places with luxurious accommodations, ample amusements, social gayety, and whatever can make the time pass pleasantly; and when they get tired of one place they can find another with fresh novelties and attractions. But, wherever they go, these people are extremely useful. They constitute the great mass of the patrons of Southern winter resorts. Their numbers each year are rapidly augmenting, and the money they spend contributes materially to promote those increasing facilities of travel, hotel-accommodations, and town-improvements of which all share the advantage.

But there are a good many others to whom the question, where to go to escape the inclemencies of a Northern winter, is less simple and more serious. These are invalids laboring chiefly under various forms of pulmonary trouble. When such are advised by the physician to seek a more congenial climate, the question where to go becomes urgent and often perplexing. Happy the patient advised to change his climate when the physician knows enough to give him intelligent instructions as to whither he shall proceed. Does he need a mild or a

high temperature? a damp and relaxing, or a dry and bracing air? an inland location, or the sea-side? a valley or a mountain? Should he try Bermuda, or Aiken, or Nassau, or St. Augustine, or Asheville, or any of the score of resorts recommended for pulmonary invalids? If the doctor settles the point, it is well; if not, the patient must take his chances and do the best he can to settle it for himself.

I found myself last year among those who are embarrassed by this question. With lungs badly out of order, everybody said I must escape the severities of a New York winter by going somewhere. I advised with several eminent pulmonary experts, who agreed that it might be a good thing to get away, but did not seem to think it made much difference where I went. I therefore consulted the books on American winter sanitary resorts, in order, in connection with what I had heard, to decide what course to take. The climate of Southern California has its undoubted claims which are well appreciated, but it is far away. Colorado has its advantages, but is liable to sudden and extreme changes. San Antonio, in Southwestern Texas, is unquestionably an excellent place, with its pure, invigorating air, its mild temperature, and absence of extreme cold, although fierce and frigid "northers" are liable to swoop down upon it with but little warning, and it is also a long way off—two thousand miles by rail. Florida is popular and has many attractions, but it is chiefly low, and is generally damp and malarial. No place is without its drawbacks; but, in looking over their various claims with reference to my own condition, I concluded at last that Thomasville, Georgia, promised to be as eligible as any, and thither I went.

I found the place eminently satisfactory, and, although without experience of other and rival localities, I am sure that Thomasville has advantages as a Southern residence in winter and spring which must give it increasing and decided prominence as it becomes better known. Of course, the transition from "North" to "South" in February—from bleak, stormy, ice-bound winter to the soft and sunny atmosphere and vernal aspects of flowery spring—is full of delightful sensation wherever experienced; while the change of environment in passing from a Northern to a Southern community for the first time, intensifies the pleasurable effect. But, besides this, I was much gratified by the special attractiveness of the place, and the promise it offered as a healthy residence.

Thomasville, the capital of Thomas County, Georgia, is located two hundred miles from the Atlantic coast, fifty-five miles from the Gulf, within twelve miles of the Florida border, and on the Savannah, Florida, and Western Railroad. It stands upon a ridge or plateau covered by extensive pine forests, and at a height of about three hundred and fifty feet above tide-water. It is an old town, with upward of four thousand inhabitants, pleasantly laid out with wide streets, and containing many noble and stately trees—one superb oak

being worth going every day to see. The air is pure, dry, and balmy, from the all-encompassing pine woods, through which radiate many walks and diversified drives in all directions. There are half a dozen different kinds of churches, and several considerable hotels. The "Piney Woods Hotel" and the "Mitchell House" are large, new, and first-class. The former has a frontage of over four hundred feet, is three stories high, and with broad piazzas front and rear. It will accommodate three hundred guests, has all the modern accommodations and improvements, except an elevator, and is so thoroughly well kept as to lead to the remark, which I heard frequently made, that the "Piney Woods is the best hotel South." There are lesser hotels and numerous boarding-houses, of the merits of which I know nothing, but heard them very well spoken of. The weather in Thomasville I found mild and agreeable. It rains there often, and sometimes hard, but the sandy ground quickly dries. The average winter temperature is given at 54·55° Fahr., but it is not to be inferred that they have no cold weather there. They have at times heavy frosts and ice, and report a fall of snow once in the last fifteen years. But the "cold spells" are short, and the prevailing warm and sunny weather invites to out-of-door life, which is the main thing, for, as Dr. Felix Oswald says, consumption is a "house disease."

I do not suppose there are any magical healing powers for pulmonary invalids in the Thomasville atmosphere, but I should hesitate to say that it may not be very favorable to them. An old physician of the place, Dr. T. S. Hopkins, after twenty years' medical experience in the pine forests of Southern Georgia, speaks as follows upon this point in the "Atlantic Medical Register": "Having for many years, in my travels through this section of country, noticed the almost entire absence of consumption among the people, I addressed letters to a large number of physicians practicing in the district, asking them to report to me the number of cases of consumption coming to their knowledge during the previous years. I received replies from twenty engaged in active practice, and representing a population of fifty thousand eight hundred and eighty-seven. The total number of cases reported was *three*. I have no reason to doubt the honesty of this report. A climate in which the disease so rarely occurs is certainly worthy of a trial by those who have it." As for myself, I can by no means report "cured" at Thomasville; but my case was undoubtedly improved there. And, as I might have died in New York, just according to the danger of this contingency, Thomasville must be entitled to the credit of saving my life. At any rate, the trial was a good thing, and I esteemed myself fortunate in the place selected.

In the matter of recreations, which is of considerable hygienic importance in a sanitary resort, Thomasville is quite undeveloped. There are several well-equipped livery establishments, and there is a

good deal of horseback-riding and carriage-driving on the excellent thoroughfares of the town and the pleasant roads through the woods and the farming country. But, though the prices are reasonable, this amusement is only for those who can pay for it. There was no bowling-alley last year, though one was promised for the ensuing season. But what is most needed of all in such a place is a gymnasium, where active and regular exercise may be taken to counteract the besetting evils of idleness, and as an indispensable means of improving the health. Our constitutions are made for activity, and only those who cultivate their bodily powers by systematic exercises really know what enjoyment there is in well-earned appetite and invigorated life. The facilities for simple but adequate gymnastic exercises do not cost much, and, while the large majority of visitors would probably not patronize them, they would yet be invaluable to many. In the absence of a regular gymnasium, however, I fell back on Wood's five-dollar "Parlor Gymnastics," which can be carried in a satchel and used anywhere, and which really answers a most excellent purpose. They have a Library Association at Thomasville, and a very pleasant reading-room, but a larger stock of books is much needed.

There was, however, one never-failing source alike of interest, amusement, and instruction, which, though not confined to Thomasville, very much alleviated the monotony of my stay; I mean the "colored brother." As an abstraction from much reading I had long known him; but it was different to come upon the negroes in concrete mass, in their *habitat*, so as to observe the attributes of the actual object in a composite state of society. This was all new to me, and, with my old abolition education of strong convictions and little real knowledge, I found extreme interest in studying the negro direct, as a social object-lesson. He is playing his new part as citizen, voter, politician, laborer, learner, litigant, and Christian, with curious and instructive results; and in observing his treatment in the courts, in getting the views of individuals, in looking into the colored schools, but, most of all, in attending the so-called religious services in the colored churches, a good deal of time was pleasantly and usefully occupied, and I came to the conclusion that the more Northern people go South and see for themselves the more they will know of those facts which it is very important they should better understand.

# THE SPIRIT AND METHOD OF SCIENTIFIC STUDY.*

By Professor J. P. LESLEY.

MY FRIENDS: I have the honor to address you this evening as an association of representatives of American science in all its branches—as students of the sky and all its elemental forces, of the earth and all its mineral constituents, of the animal and vegetable kingdoms in their past and present ages, of the history and constitution of the human race—and I may be easily pardoned for some trepidation in view of the drafts you may have drawn in advance on my slender exchequer. I have lain awake o' nights, like my predecessors, reflecting how I should meet my liabilities. And like them, no doubt, I find myself poorer than when, a year ago, I contracted them. You would scorn to receive in payment my promissory notes or mortgages on my castles in Spain. You will accept nothing but gold and silver, in bullion or in coin; and that is what troubles me.

There were once halcyon days for orators: the world of knowledge limited, and canopied with rosy clouds of curious speculation; the birds of fancy singing in every bush; the dew of novelty glittering on the fields. Science was then an early morning stroll with sympathetic friends, uncritical and inexpert, to whom suggestions were as good as gospel truths. Then, such a reunion as this to-night was a sort of picnic-party, at some picturesque place on the shore of the unknown, hilarious and convivial.

All that has passed away. The sun of science now rides high in heaven, and floods the earth with hot and dusty light. What was once play has turned to serious toil. Shadows are short. Objects present themselves in well-defined and separated shapes for critical examination. The few and early risers have become a multitude. The tumult of occupations distracts the studious observer. No one lends ear to chit-chat. All are hurried. Critics abound. "Say what you want, and go; or tell us something absolutely true and useful," is the introduction to every conversation. Morning, noon, and night, men demand, not the agreeable, but the necessary. The age of romance in science is part of the forgotten past. The new world has grown gray-haired in fifty years, intolerant of the irresponsibility, the sportiveness, the poetry, the music, the superstitions, the affections, of its youth; dealing only in hard facts, and in their causes and consequences; weighing and measuring all things; analyzing all things; collating, comparing, and classifying; insisting upon investigation at all points; formulating rigid laws; scoffing at the unseen and unknowa-

* Address to the American Association for the Advancement of Science at Ann Arbor, August 26, 1885, by the retiring President of the Association. Reprinted from "Science."

ble; and transmuting the fear of God and the hopes of heaven into a zeal for the exact determination of the units of force, and a confident expectation that railroads will soon traverse all the unoccupied regions of the earth, and malleable steel replace wood in the mechanic arts.

You represent this new world, grown so suddenly old, learned, utilitarian, and critical. Your orators have a hard time of it.

Am I to be the mouth-piece of the outside world, setting forth in order what it has expected of you—its praise, its blame? Nay, what care you for praise from uninspired lips? Or what care you for blame from the vulgar herd who comprehend neither your purposes nor your methods?

Am I to be your mouth-piece to inform this outside world of what the community of science which you partly represent has been about the last twelve months, giving it such a catalogue of facts discovered, and theories established or improved, that it shall stand amazed, and bless its stars and worship? Then this address would simply be a grandiloquent stage-aside in the drama of this meeting, and no address to you.

Must I, then, speak to you as a fellow-worker in science, contributing some fresh gifts to our common stock of truths? But that would be better done, if done at all, by reading a paper on the subject in the section to which I properly belong.

I did, indeed, hesitate a while before I rejected a temptation to discuss before you this evening one or two subjects on which I have reflected for many years—for instance, the important *rôle* which the chemical solution of the limestone formations has played in the grand drama of the topography of the globe; the absolute inconstancy of the ocean-level; the function of variable deposition in closed basins in elevating the plane at which coal-vegetation repeated itself; the influence which anticlinals and synclinals *en échelon* have exercised in originally directing, and afterward perpetually shifting, the systems of river-drainage, as the general surface became lower and lower through erosion; the extraordinary differences in the amount and rate of erosion in different parts of the same region, due to the various heights and shapes of the plications—but a deep sense of insufficiency for properly handling such great subjects deterred me from the attempt. They demand the largest treatment, the fullest illustration, and the long co-operation of many minds. All the great transcendental questions of science remain open to research; not one of them has as yet been answered satisfactorily; all answers have been premature, and most of what has been published for such seems to me puerile; yet the disposition to deal in transcendental science seems to grow daily stronger. There are no laws, however, against initiation into Alpine clubs. If men choose to run fatal risks for notoriety, let them do so, in the name of all that is chilly and unprofitable; but let them not pretend that, when they reach the summit of some Jungfrau or

Matterhorn, their demon of adventure shows them all the kingdoms of the world of science, and the glory of it; for in fact, the inaccessible sky surrounds them still, and clouds obstruct their vision in every direction. I have no fancy for such mountain-climbing, and think lightly of exploits so barren of results.

I seize the occasion, rather, to awake to your remembrance some thoughts of common interest, which the multiplying avalanches of facts and theories threaten to bury out of sight, as the pure ice of the glacier gets covered over with a sordid sheet of *débris*, perpetually tumbling from the cliffs between which it flows.

Consider, then, first, that the final cause of a glacier is not to carry moraines, lateral or medial; that these are mere accidents of its existence; and that, were it endowed with intelligence, it would feel little interest and less pride in the heterogeneous, variable, and for the most part useless, burden, which it can not escape, and throws away at the close of its career. Such are the loads of science which we are compelled to carry forward through life, in the forms of fact and theory; misshapen, accidental droppings upon us from our local surroundings; fragmentary specimens of knowledge, of which we construct our confused and shapeless heaps of learning, most of which is of little use, either to ourselves or to the world. The life of the glacier is an elaboration of the universal moisture into snow, *nevé*, and pure ice, by a slow process of internal constitution; and such is the happy destiny of the true man of science, worked out in wisdom of character, apart from all accidental accumulations of learning, and mainly irrespective of them.

Let us avoid the sacrifice of character to science. As the saying of Jesus of Nazareth, that the sabbath was made for man, not man for the sabbath, has rung through the centuries, a tocsin of alarm to rouse mankind to resist ecclesiasticism, so let the warning cry fill the air of our association, from meeting to meeting, that science is our means, and not our end. Self-culture is the only real and noble aim of life. And as the magnificence, beauty, and utility of a glacier, as a perpetual reservoir of solid moisture, are not gauged by the size, arrangement, or constitutional features of its moraines, neither are the greatness and usefulness of the philosopher measured by his amount of the knowledge of the physical fact-and-theory science of the times.

Of all kinds of intellectual greatness, the greatest is achieved by the philosopher who stands before the thinking world as a model of scientific virtue; deaf to flattery; insensible to paltry, hostile criticism; patient of opposition; dead to the temptations of self-interest; calmly superior to the misjudgments of the short-sighted; whom nothing diverts from the endeavor to live nobly, and to whom noble means are as indispensable as noble ends; in whom the most brilliant successes foster neither vanity nor arrogance; to whom fame is unimportant, and poverty a trivial circumstance; whose joys, like fragrant

breezes from an encircling landscape, come from the surrounding friendship of the general world, to whose best interests the noble heart is forever loyal.

Another subject for serious reflection is the over-accumulation of scientific information. To broach it before such an assembly may seem to require some apology. Certainly the feeling prevails that the world can not have too much science. But the science of learning and the science of knowledge are not quite identical; and learning has too often, in the case of individuals, overwhelmed and smothered to death knowledge. The average human mind, when overstocked with information, acts like a general put in command of an army too large for him to handle. Many a vaulting scientific ambition has been thus disgraced. Nor is this the only danger that we run; for the accumulation of facts in the treasury of the human brain has a natural tendency to breed an intellectual avarice, a passion for the piling-up of masses of facts, old and new, regardless of their uses. In the great game of our spiritual existence, facts are mere counters with which to play the game. A million of them are worth nothing, unless the player knows how to play well the game; and, when the game is over, the worthless counters are swept back into the drawer. And the danger pursues us to higher and higher planes of science. Not only the avarice of facts, but of their explanations also, may end in a wealthy poverty of intellect, for which there is no cure. Even the sacred fires of research may be allowed to burn too long, until, in fact, they turn the investigator into a mere miser of ideas. As for those who are not themselves original investigators, but busy themselves incessantly in appropriating the secretions of research at second hand, how often it happens that the richest additions of reliable theories to the stock of their ideas, even to a point where they suppose themselves, and are supposed by others, to know all the conclusions arrived at by past and present inquirers, leave them as thinkers just what they were at first—incompetents; mere ill-hung picture-galleries; disarranged museums; complicated inventions which will not work; costly expeditions for discovery, frozen fast and abandoned in the polar ice!

A certain temperance in science is obligatory from another point of view. As mere wealth of possessions can not guarantee happiness, neither can a superfluity of learning insure wisdom. When the body from overfeeding grows plethoric, its vital energies subside and its life is endangered. The intellect may be mischievously crammed with science. How much we know is not the best question, but how we got what we know, and what we can do with it; and, above all, what it has made of us. The tendency of training now is to subordinate the soul to that which should be merely its endowment and adornment; to turn the thinker into a mere walking encyclopædia, text-book, or circle of the mechanic arts; not to produce the highest type of man. What ridiculous and pitiable creations are these!—an author-

ity in physics who can not speak the truth? a leader in natural history who is given over to the torments of envy? a god in chemical research sick of some false quotation? a youthful prodigy of mathematical science tottering with unelastic steps and outstretched arms to grasp his future fame? Yet no one will deny that the intemperate pursuit of any branch of science has a tendency to produce such characters, by elevating to undue importance the individual accumulation of scientific facts and scientific theories, to the neglect and depreciation of that spirit of truth which alone can inspire and justify an earnest study of the material universe. I beg you to reflect that it is as true of science as of religion, that the mere letter of its code threatens its devotee with intellectual death, and that only by breathing its purest spirit can the man of science keep his better character alive—that indefinable spirit which, in its intimate and essential nature, has little to do with the number of facts discovered or theories accepted; a spirit which merely exercises itself in research, and accepts discoveries as delightful accidents; a spirit which walks the paths of science, not as if they were turnpikes converging upon some smoky and squalid focus of toil-wearied population, but as if they had been graveled and flower-bordered for it through some princely park; a spirit of natural and cultivated nobleness, sweetened by boundless friendship for the world and all that lives therein; just and true to all men worthy or unworthy, proud without vanity, industrious without haste, stating its own griefs as lightly as an angel might, and generously bringing help to the discouraged and forlorn. In every one of us there is this genius, if we did but know it; and, as Emerson well says, the moral is the measure of its health.

I have been saying, then, that we should pursue science, like any other business of this life, with a distinct and unwavering intention to ennoble our own characters. It were a trite addition to propose that the pursuit be made ancillary to the public good. "The love of science" is a phrase which has been greatly glorified in popular discourse; and if the phrase be confined to its true meaning—a zealous admiration for all that is beautifully true and useful in Nature—it can not harm us in the practice of our profession. But when the imagination has exhausted itself in transcendental ecstasies over an ethereal sentiment so named, but undescribed except in poetry, what wiser or better thing can we say of any branch of physical or natural science, cultivated by our association, than that its votaries are knowingly or unknowingly bettering the condition and character of mankind? Every advancement in science is, of its own nature, an improvement of the commonwealth. Every successful study of the laws of the world we inhabit inevitably brings about a more intelligent and victorious conflict with the material evils of life, encouraging thoughtfulness, discouraging superstition, exposing the folly of vice, and putting the multitudes of human society on a fairer and friendlier footing with one another.

The arts of philanthropy are, therefore, as direct an outcome of science as the lighting of the public streets or the warming of our homes. Cruelty and shame are products of the night. The daylight is a friend to friendliness. The progress of civilization and the progress of science are alike typified by the progressively brilliant and general illumination of cities. So, in old times, human sacrifices and piracy ceased wherever the worship of the Tyrian Melcarth yielded place to the philosophy, *belles-lettres*, and fine arts of the genial and beautiful Delphic Apollo, the civilizer, the far-shiner, the sun of Grecian righteousness, whose initiated became the educators of the modern world.

And yet these two magic words, "initiation," "education," have meanings directly the reverse of one another—the one a *going in* to learn the secrets of esoteric doctrine, unsafe for publication because immature; the other a *being led out* from ignorance to knowledge, from helplessness to the active performances of life. The idea of universal education is wholly modern—in fact, a product of the century in which we live. It is democracy in the world of intellect; it is the doctrine of equal human rights applied to the possessions of the human brain; it is the apotheosis of common sense; it demands the distribution of knowledge in adequate quantity and quality to all who live and all who are to live upon the earth. How this is to be accomplished is the greatest of the questions of the day, and it especially concerns us as members of an association for the advancement of science.

I do not intend to discuss the subject, to define the quantity and quality of knowledge adequate for the various classes of human society, or to propose any plans for its distribution. All I wish to say about it is, that it seems to me Nature limits both the responsibilities of teachers and the rights of learners more narrowly than is commonly supposed. The parable of the sower is a good reference for explanation. Most of the surface of the globe is good for little else than cattle-ranches or sheep-farms, and the large majority of mankind must in all ages be satisfied with the mere rudiments of learning. What they want is unscholastic wisdom with which to fight the fight of life, and they must win it for themselves. Only a limited number of persons in any community can acquire wealth of knowledge, and the only thought on which I wish to insist is this: these few must also get it for themselves, and, moreover, must work hard for it.

It is a hackneyed aphorism that there is no royal road to knowledge, although an incredible amount of pains has been taken to make one. Nature in this affair, as usual, has been a good, wise mother to us all; for it is not desirable to make the acquisition of knowledge easy, for the main point in scientific education is to secure the highest activity of the human mind in the pursuit of truth—an activity tried and disciplined by hardship and nourished on hardy fare. The quantity of food is of less importance; everything depends on establishing a good constitutional digestion. The harder the dinner is to

chew, the stronger grows the eater. Canned science as a steady diet is as unwholesome for the growing mind as canned fruits and vegetables for the growing body. The wise teacher imitates the method of Nature, who has but one answer for all questions: "Find it out for yourself, and you will then know it better than if I were to tell you beforehand."

But who can be a wise teacher who has not been wisely taught? The spirit of this scientific age favors a universal manufacture of condensed milk to ease and cheapen the toil of bringing up its infants. It finds the bottle of literature more convenient than the breast of Nature. It prefers a large family of puny children to a few young heroes. The stalwart ancients exposed their unfit offspring to the wolves; we moderns exhaust the resources of art to preserve their worthless and painful lives.

This is the spirit which invents a thousand futile plans for compacting the universe to a size so small, and a shape so simple, that it can be grasped without much effort by the tiniest and feeblest hands. Will it be an unpardonable crime for me to say that I recognize the same spirit in the present popular rage for an over-classification, unification, and simplification of science; for ultra-symmetrical formulæ and excessive uniformity in nomenclature; with an avowed reference to ease of learning and convenience of teaching, the saving of time in the acquisition of facts, and the diminution of brain-waste in collating them for use; in one word, to the making of science easy, despite the inexorable decree of Nature, that it always shall be and always ought to be difficult? For the genius of the creation is visibly hostile to that uniformity, symmetry, and orderly simplicity which the text-book endeavors to establish. No logical consistency for her! No stiffening of the fact-producing energies into fact formularies will she endure. Hardly has a manual issued from the press, but it is mutilated by her Puckish fingers. No sooner has some school of theorists erected a stately structure in simple grandeur, than it is shattered by the lightning of a new revelation. There is no rest, no peace, in our believing. Our libraries contain little else than such spoiled palimpsests. The broad fields of science are covered with such ruins; and those who have grown old in traveling far and wide across them would find little cause for singing pæans to the exploits of science were it not for the fact that the function of science is not to organize Nature, but by the laborious study of Nature to organize the human mind and inform it with the very genius of Nature, original, unsymmetrical, indefinable, unclassifiable, changing its attitudes and operations every instant, and escaping easily from all the toils of scholastic unification which we spread for it. The work of the student can not be simplified, can not be made easy, if it is not to fail in its great purpose, the production of a genuine man of science. The foolish nurse thinks it her duty to carry the child always in her arms; but the test of a good education

is the ability of the child to carry its nurse, and this it can only attain to through the discipline of toil—toil which at first conceals itself under the gracious guise of sports, gymnastics, and adventures, and afterward takes the shape of experimental failures and useless constructions, but all as free, untutored, and original as the laughing, wasteful, and ungovernable pranks of Nature. But I have followed long enough, perhaps you will think too long, this train of thought. Let me suggest another.

It is a familiar fact that great discoveries come at long intervals, brought by specially commissioned and highly endowed messengers, while a perpetual procession of humbler servants of Nature arrive with gifts of lesser moment, but equally genuine, curious, and interesting novelties. The excitement of the pageant incapacitates us for reasoning rightly on its meaning. From what unknown land does all this wealth of information come? Who are these bearers of it? and who intrusted each with his particular burden, which he carries aloft as if it deserved exclusive admiration? Why do those who bring the best things walk so seriously and modestly along, as if they were in the performance of a sacred duty for which they scarcely esteem themselves worthy; while those who have little to show, or things of inferior or doubtful value, strut and grimace magnificently, as if they felt themselves the especial favorites of Nature, push to the front, speak loudly to the multitude, and evidently deem themselves entitled to uncommon honors?

In this procession of science, in this interminable show of discovery, two facts arrest attention: first, the eager gaze of expectation which the crowd of lookers-on direct toward the quarter from which the procession comes, and their unaccountable indifference to what has already passed; and, secondly, the wonderful disappearance, the more or less sudden vanishing out of the very hands of the carriers, of a large majority of the facts and theories of which they make so pompous an exposure; few of them, however, seeming to be aware that thereby they have lost their right to participate in the pageant, and should retire from it into the throng of spectators, at least until good fortune should take pity on them, and drop some new trifle at their feet to soothe their wounded vanity.

You will not suspect me of depreciating the value of any real discovery, be it merely the finding of a Californian bird on the shore of Massachusetts Bay, or detecting with the naked eye the blazing of a variable star before any telescope had noticed it, or finding some Hadrosaurus bones in a New Jersey marl-pit, or a Paradoxides at the Quincy quarries? Such accidents have all the importance of trumpet-notes sounding to boots and saddle. But, after all, the trumpeter is only a trumpeter, although he may imagine himself the colonel of the regiment or a general in the army; and, indeed, it has happened that to such accidents Science has owed some of her best physicists and

naturalists. But it was not these, their first and therefore most enjoyable discoveries, that made them what they afterward became, nor had they at the outset even the right to an opinion on the value of their finds. Years of strenuous and unrenowned exertion had to follow, in which they published little or nothing new, but gathered up the old, and rediscovered, by experiment and observation, what the records of the past preserved.

What I deprecate is the claim to special attention made by inexperienced stumblers on forgotten or unnoticed facts, remarkable or otherwise, on the sole ground of the discovery. I deprecate the folly of the youth who, because he has found a spear, leaps into the empty chariot of Achilles, and, calling on the Grecian host to follow him, lashes the horses for an immediate attack on Troy; nor finds it out until he is half-way across the plain, that he rides alone, and to destruction. I feel no admiration, no respect, for the audacity with which our young recruits of science rush unpanoplied into the thick of a discussion involving the greatest thinking of the age. They act like animals at a conflagration. I hear on all sides a noisy tumult of untrained intellects. Shall such themes as the nebular hypothesis, the probable solidity or fluidity of our planet, the metamorphosis of rocks, the origin of serpentine or petroleum, the cause of foliation, the stable or unstable geographical relationships of continent to ocean, the probable rate of geological time, the conditions of climate in the ages of maximum ice, the probable centers of life-dispersion, the unity or multiplicity of the human race, the evolution of species, be babbled over by men, the amount of whose efficient work in any branch of science is measurable with a foot-rule; while those whose entire lives have been but one exhausting struggle with the shapes which people the darkness of science speak with bated breath and downcast eyes of these great mysteries?

There is a shibboleth by which tyros in science can always be detected—their habitual employment of the words "doubtless," "certainly," and "demonstrated." To their inexperience of the universality of error, every new statement in print over a name noted in science reads like a revelation of the absolute; and every conclusion at which they themselves arrive, after a more or less superficial study of the limited number of facts which accident has given them the opportunity to observe, seems a conclusion too real to be impugned. I love the remembrance of my youth, but I regret its dogmatic impertinences. Young votaries of science draw their inspiration from the maxim which best suits them—"Try the value of old truths by new discoveries." The veterans of science reverse the rule, and test all new discoveries by a world of half-forgotten facts and well-established principles. The advancement of science is accomplished by the push and pull of these two ruling motives. No science were possible if the aged could suppress the youthful, or the youthful could ex-

tirpate the aged. But as surely as the agnosticism of age is a witness to the weariness of fruitless speculation, so surely the confidence of youth that every movement must of necessity be forward is a proof of insufficiency.

Let the military art instruct us. The raw recruit is satisfied if old Blücher waves his sword, shouting, "Vorwärts!" But the sobered veteran is prepared to see in flank-movements, in retreats, in halts and intrenchments, steps of the campaign as necessary as any charge at double-quick on hostile lines, or a steady march in column into the enemy's country. Let us suppose that in the last twelvemonth not one surprising discovery in any region of the globe has been made; that a hundred previously reported facts have been examined and pronounced untrue; a hundred printed memoirs, widely read and criticised, been proved mistaken or absurd; a hundred long-accepted generic or specific names, fossil or recent, have been expunged from the lists; and that others, like *Halysites catenulata* or *Spirifer disjuncta*, have lost their characteristic values; suppose any amount of doubt to have been thrown upon any number of popularly accepted theories, by failures in applying them to practice, like the theory of the anticlinal location of gas-wells; in a word, suppose any amount of smashing in any department of the great crockery-shop of transcendental or applied science—what does it imply but the tendency of all inquiry, observation, investigation, and experiment toward the betterment, which is the only true advancement, of science? As, in the animal kingdom, the peaceful kinds are offset and held in check by analogous carnivores, for fear of over-population, so, in the world of thought, the constructive theorists are perpetually preyed upon by a corresponding class of natural enemies, the destructive critics, which keeps the field open and the air sweet. The destruction of effete knowledge is the perennial birth of that science which can not be destroyed. But, in recognizing the fact, we should remember that there is a science of items and a science of fundamentals, which bear a relation to each other, like that which subsists between the individuals of a species and species *per se*; and that an indefinite multiplication of individuals may go on without any visible modification of their specific character. The population of Europe has grown in the last century from a hundred and fifty to three hundred and twenty millions of souls; but they are the same Teutons, Celts, and Slavs as ever. On the other hand, the curve of population for France is almost a horizontal straight line; but their national advancement has been phenomenal. What I wish to illustrate is this evident truth, that not by the mere increment of number of facts learned, not by the mere multiplication of discoverers, teachers, and students of those facts, but by the elevation of our aims, by the enlargement of our views, by the refinement of our methods, by the ennoblement of our personalities, and by these alone, can we rightly discover whether or not our asso-

ciation is fulfilling its destiny by advancing science in America. If, unhappily, our meetings should rather tend to cultivate a love for *bric-à-brac* in science, if the stimulation and gratification of a *quasi*-animal curiosity for scientific novelties be fostered, if our discussions should become hot-beds of a more vigorous vegetation of personal vanity, intellectual pugnacity, lust for notoriety, literary jealousies, conceited reclamations, petty ambitions, or pecuniary schemes, how are our day and generation to be benefited or improved? If our attention become restricted to the details of the creation, and to the smaller manœuvres of the forces of Nature; or if, on the other hand, we become habituated in the indulgence of vague generalizations, suggestions of possible theories, and half-completed or merely sketched and outlined hypotheses—how are we ourselves, as workers of science, to escape deterioration?

I can not shake off a suspicion that we talk and write too much; that the whole world talks too much; and that the golden time for silence is precisely then when we come together to talk. Were each of us to utter only what he absolutely knows, what he is quite sure of, what he has unimpeachable facts in sufficient number to confirm—what a sudden illumination would overspread our meetings, glorifying our science, and reinspiring us all! But I turn from the Utopian fancy, and invite your attention to a very different theme.

There is a topic which I think should be frequently considered by all who engage in scientific pursuits; and by none so earnestly as by those who are ambitious to reach the higher points of view, from which to survey and describe those systematic combinations of phenomena which are more or less panoramic: I allude of course to generalizers or discoverers of natural laws, and the professional teachers of such laws; while those who deal in itemized science, the mere observers of isolated facts, discriminating specimens and naming genera and species in the animal, vegetable, or mineral worlds, and especially such as occupy themselves with geographical and geological studies in detail, stand in less need of having it pressed upon their attention, because in their case it insists upon its own necessity.

I allude to what is technically known among experts as "dead-work."

This topic has to be treated in the most prosaic style. To describe dead-work is to narrate all those portions of our work which consume the most time, give the most trouble, require the greatest patience and endurance, and seem to produce the most insignificant results. It comprises the collection, collation, comparison, and adjustment, the elimination, correction, and re-selection, the calculation and representation—in a word, the entire first, second, and third handling of our data in any branch of human learning—wholly perfunctory, preparatory, and mechanical, wholly tentative, experimental, and defensive—without which it is dangerous to proceed a single stage into reasoning

on the unknown, and futile to imagine that we can advance in science ourselves, or assist in its advancement in the world. It is that tedious, costly, and fatiguing process of laying a good foundation which no eye is ever to see, for a house to be built thereon for safety and enjoyment, for public uses or for monumental beauty. It is the labor of a week to be paid for on Saturday night. It is the slow recruiting, arming, drilling, victualing, and transporting of an entire army to secure victory in one short battle. It is the burden of dead-weight which every great discoverer has had to carry for years and years, unknown to the world at large, before the world was electrified by his appearance as its genius. Let us examine it more closely: it will repay our scrutiny. Those of you who have been more or less successfully at work all your lives may get some satisfaction from the retrospect, and those who have commenced careers should hear what dead-work means, what its uses are, how indispensable it is, how honorable it is, and what stores of health and strength and happiness it reserves for them.

My propositions, then, are these: 1. That, without a large amount of this dead-work, there can be no discovery of what is rightly called a scientific truth. 2. That, without a large amount of dead-work on the part of a teacher of science, he will fail in his efforts to impart true science to his scholars. 3. That, without a large amount of dead-work, no professional expert can properly serve, much less inform and command, his clients or employers. 4. That nothing but an habitual performance of dead-work can keep the scientific judgment in a safe and sound condition to meet emergencies, or prevent it from falling more or less rapidly into decrepitude; and, 5. That in the case of highly organized thinkers, disposed or obliged to exercise habitually the creative powers of the imagination, or to exhaust the will-power in frequently recurring decisions of difficult and doubtful questions, dead-work and plenty of it is their only salvation; nay, the most delicious and refreshing recreation; a panacea for disgust, discouragement, and care; an elixir vitæ; a fountain of perpetual youth.

In expanding these propositions, I would illustrate them in some such homely ways as should make them seem near and familiar principles of conduct; and of course I can only do this out of the experience of my own life, and from observation of what has happened in the limited sphere of one department of scientific inquiry; but that should suffice, seeing that work is work, and science science, however various may be minds and their pursuits.

First, then, is it so that scientific truths can not be discovered without a large amount of preliminary dead-work? Surely no one in this assembly doubts it who has established even one original theory for himself, or won for it the suffrages of judges capable of weighing evidence. Now, the immense disproportion in numbers between theories broached and theories accepted is the best proof we could have,

not only of the value and necessity of dead-work, but of the scarcity of those who depend upon it as a preparatory stage of theorizing. And, moreover, not theories only, but simple statements of fact believed and disbelieved, that is, finally accepted or finally rejected, exhibit the like numerical disproportion, and betray a general carelessness or laziness of observers; at all events, their manifest lack of appreciation of the value and necessity of the dead-work part of observation, which imperatively must precede any clear mental perception of the simplest phenomenon, before the attempt is made to establish its natural relationships, and present it for acceptance as a part of science.

A geologist travels far to collect fossils at a particularly good locality, stops there a day or two, fills his valise, and returns to publish a paper on it. What is his paper worth? Were he first to spend a week in making himself acquainted with the whole vicinity, a second week in making measured sections of all the cognate outcrops in the neighborhood, a third week in carefully differentiating the specific horizons, and a fourth week in verifying their reliability, and in correcting his first mistakes, then, surely, whatever labor he should afterward expend upon his collection of life-forms would have its full value, and any paper he might write would be an important contribution to his branch of science.

I have known men settle to their own satisfaction some of the greatest problems in geology by a flying reconnaissance; triumphantly overturning a mass of accumulated science slowly brought to demonstration by many years of conscientious dead-work, which they did not seem to think it worth their while to verify. I have known men reclassify the elements of a geological system by a few sections, not a single one of which was properly measured by them, or could be properly put on paper in a graphic form for precise comparison. I have known men make what they called a geological map, without having run a single instrumental line themselves; with every outcrop inaccurately placed; with only here and there an accidental note of strike and dip, and even this not oriented with a close approximation to precision; covering a region requiring the study of many months with a few weeks of what they fondly called field-work, and basing on such a map generalizations of the first rank, for which they expected the world of science to give them credit—which in the long run it certainly will, but not the kind of credit they anticipate.

Now, the experience of a long and active life of science has trained me to regard all such work as careless work, lazy work. Not that such workers are lazy men in the common meaning of the word; on the contrary, they are busy, bustling, active, energetic, indefatigable men; in fact, too much so. In science there is a laziness of quite another definition—namely, a chronic dislike, a deep-seated disability, for the dead-work which first disciplines to accuracy, then makes

patient and cautious, and finally bestows the clearest intelligence and largest comprehension of phenomena. And this fatal laziness is fostered by a strange misunderstanding, a fancy, sometimes a downright conviction, that the dead-work of science can be done for us by some one else, so as to save our time and strength for speculation, for thought, for fine writing—can be done by menials, employés, assistants, colleagues, special experts, by any one rather than by ourselves. Can we not, in fact, often find it already done for us, and even better done than we could do it? Then, why not let inferior minds occupy themselves with this laborious and time-consuming address of special skill? Can we not, for instance, hire transit-men to lay out and measure our sections, and artists to draw them? Why should a paleontologist take the pencil between his own fingers in studying species, when he has trained photographers and lithographers at his command? Why waste precious weeks and months in tramping and climbing, in measuring and plotting, while glory calls us and the scientific world is impatiently waiting for our conclusions? Thus possessed by the demon of scientific haste, we continually spoil our own performances and disappoint the expectant but not at all impatient world. Could our vanity permit us to know the fact, the impatience is entirely our own, and, if indulged, is sure to be roundly punished.

No, dead-work can not be delegated. The man who can not himself survey and map his field, measure and draw his sections properly, and perfectly represent with his own pencil the characteristic variations of his fossil forms, has no just right to call himself an expert geologist. These are the badges of initiation, and the only guarantees which one can offer to the world of science that one is a competent observer and a trustworthy generalizer. Nor has one become a true man of science until he has already done a vast amount of this dead-work; nor does one continue in his prime, as a man of science, after he has ceased to bring to this test of his own ability to see, to judge, and to theorize the working and thinking of other men. But enough of this.

My second proposition was, that no teacher of science can be successful who does not himself encounter some of the dead-work of the explorer and discoverer; who does not discipline his own faculties of perception, reflection, and generalization by field-work and office-work, independently of all text-book assistance; who does not himself make at least some of the diagrams, tables, and pictures for his class-room, in as original a spirit, and with as much precision of detail, as if none such had ever been made before, and these were to remain sole monuments of the genius of investigation. What the true teacher has to do first and foremost is to wake up in youthful minds this spirit of investigation *ab initio*. The crusade against scholastic cramming promises to be successful; but the crusade against pedagogic cramming has hardly yet been organized. How is the scholar to be made an artist

if the teacher can not draw? The instinct of imitation in man is irresistible. Slovenly drawing on the blackboard—sufficient evidence of the teacher's imperfect information and inaccurate conception of facts, the nature of which he only thinks he understands—can do little more than raise a cold fog of suspicion in the class-room, by which the tender sprouts of learning must be either dwarfed or killed. But even slovenly diagrams are preferable to purchased ones, for whatever diminishes the dead-work of a teacher enervates his investigating and thereby his demonstrating powers, and lowers him toward the level of his scholars.

Were I a dictator, I should drive all teachers of science out into the great field of dead-work, force them to go through all the gymnastics of original research and its description, and not permit them to return to their libraries until their note-books were full of their own measurements and calculations, sketch-maps and form-drawings, severely accurate and logically classified, to be then compared with those recorded in the books. What teachers fail to keep in mind is this: that learning is not knowledge; but, as Lessing says: "Learning is only our knowledge of the experience of others; knowledge is our own." No man really comprehends what he himself has not created. Therefore we know nothing of the universe until we take it to pieces for inspection and rebuild it for our understanding. Nor can one man do this for another—each must do it for himself—and all that one can do to help another is to show him how he himself has morsellated and recomposed his small particular share of concrete nature, and inspire him with those vague but hopeful suggestions of ideas which we call learning, but which are not science.

My third proposition was, that an expert in practical science can command the respect and confidence of his professional fellows, and, through their free suffrages, build up his own reputation in the learned and business worlds, only in exact proportion to the amount of good dead-work to which he voluntarily subjects himself. For, although the most of it is necessarily done in secrecy and silence, enough of it leaks out to testify to his honest and diligent self-cultivation, and enough of it must show in the shape of scientific wisdom to make self-evident the fact that he is neither a tyro nor a charlatan. More than once I have heard the merry jest of the Australasian judge quoted with sinister application to experts in science. When a young colleague, just arrived from England, asked him for advice, he answered, "Pronounce your decisions, but beware of stating your reasons for them." Many an ephemeral reputation for science has been begot by this shrewd policy; but the best policy to wear well is honesty, and honesty in trade means selling what is genuine, well made, and durable, and honesty in science means, first, facts well proved, and then, conclusions slowly and painfully deduced from facts well proved, in sufficient number and order of arrangement to exhaust alike the sub-

ject and the observer. Reap your field so thoroughly that gleaners must despair. Fortify your position, that your most experienced rival can find no point of attack. Lay your plans with such a superfluity of patient carefulness that Fate itself can invent no serious emergency. Demonstrate your theory so utterly and evidently that it shall require no defender but itself. Die for your work, that your work may live forever. Forget yourself, and your work will make you famous. Enslave yourself to it, and it will plant your feet upon the necks of kings, and your mere Yes or No will become a law to multitudes. This is what the dead-work of science, when well done, does for the expert in science.

My fourth proposition—that only the habitual performance of dead-work can preserve the scientific intellect in pristine vigor, and prevent it from becoming stiffened with prejudices, inapt to receive fresh truth, and forgetful of knowledge already won—hardly needs discussion. Human muscles become atrophied by disuse. Men's fortunes shrink and evaporate by mere investment. I pray you to imagine what I wish to say, for it all amounts to this—that the grass will surely grow over a deserted foot-path. Let me hurry to the close of this address, which I have found too serious a duty for my liking, and perhaps you also have found it too personal a preachment for yours. One more suggestion, then, and I have done.

My fifth proposition was, that the wearied and exhausted intellect will wisely seek refreshment in dead-work.

The physiology of the brain is now sufficiently well understood to permit physicians to prescribe with some assurance for its many ills, and to regulate its restoration to a normal state of health. Its tissues reproduce themselves throughout life if no extraordinary overbalance of decay takes place, if there be no excessive and too long-continued waste. For the majority of mankind, Nature provides for the adjustment between consumption and reproduction of brain-matter by the alternations of day and night, noise and silence, society and solitude, and also by the substitution of the play of fancy in dreams for the work of the judgment and the will in waking hours. We follow the lead of Nature when we seek amusement as a remedy for care. We bring into activity a rested portion of the brain, to permit the wearied parts of it to restore themselves unhindered.

This is the *rationale* of the pathological treatment of the brain. Tell an overworked president of a railway company, who falls asleep at the directors' meeting, that he must *rest*, or die of softening of the brain, and he will smile a sad reply that he *can not rest*. He is right, thus far: he can not rest his whole brain, but he can rest the cerebellum—the seat of the will-power—by bringing into higher activity and more frequent exercise the upper and frontal lobes. Let him stop thinking of leasing rival lines, and read novels and play billiards. Let him ride some youthful hobby, revive his practice on the violin, culti-

vate flowers, keep a stud and kennel, bury himself in Greek and Latin literature, collect pictures, minerals, do anything which will really interest him and keep him out of the way of railroad men and railroading, and do it with his might, with enthusiasm, even to fatigue, and do it for at least four years, and by that time his cerebellum will be all right again.

Now, what the unintermitting responsibilities of the railroad official do for the destruction of the constitution of his cerebellum, just that the overstrained exercise of the creative imagination does for the demoralization of the brain of the man of science, especially if it be as it commonly is, accompanied by business anxiety. And his only way of escape from a predestined break-down is through the monotonous but interesting occupation of his perceptive faculties in the field and at his office-table. In both he will enjoy that solitude which resembles sleep in being a medicine for the weary brain. But it is a solitude peopled with unexceptionable friends—in which Care sleeps and Pleasure wakes—a solitude in which the soul multiplies itself by alliance with all the possibilities of number and all the actualities of form; a solitude from which a man returns to the society of his fellow-men sainted by the blessing of Nature and equal to the duty of existence.

In conclusion, I must express the wish that this meeting of our association may be as delightful and as useful as any that it has ever held. Those who remember how hard we used to work at them, what a harvest of mutual confidences we used to gather at them, and what a glow of fresh enthusiasm we carried away with us from them, will know what such a wish implies. Those who come fresh to this meeting will find themselves made at home in half a dozen worlds of science at once. That is the particular character and special charm of this association, wherein it differs from all local societies, and from all conventions of workers in special branches of science and art. And, as each meeting furnishes a panoramic view of the present state of human knowledge as a whole, so, at each meeting, the old and the young in science are mingled in such friendly and confidential intercourse that the prospect extends both backward to the beginnings of inquiry and forward to its possible achievements. All good tradition is precious; and so is well-trained current inquiry, and so is sound prophetic calculation. At such a meeting as this, we enjoy the rare privilege of assisting at all three; and, when we scatter to our homes, we can hardly fail to take with us something effectual for lightening and sweetening another year of work.

# THE SOCIAL LIFE OF ARCTIC BIRDS.

By Dr. ALFRED E. BREHM.

"WHEN the great architect of the universe had finished his favorite star, the earth, Satan aspired to destroy it. From the seventh heaven he slung down a great stone toward the blooming earth; but an archangel, witnessing the wicked act, flew down faster than the falling rock, and turned it aside. The stone fell away up in the Northern Sea, and was broken up. The fragments scattered on every side and formed cliffs, some of which sunk in the deeps, while others rose black out of the waters. God in his infinite mercy pitied the bare devil's rock and made it fruitful." Thus runs an ancient Lap legend. The rock is Scandinavia; the fragments are the innumerable islands that surround it; and the fiords are the clefts between the larger stone and the fragments. One should have seen the country, rowed through the fiords, and gone down the icy mountains to the lakes and bays, to appreciate the appropriateness of the Saga.

Scandinavia is an Alpine country, and has, like Switzerland and the Tyrol, majestic glaciers, musical, dancing mountain-brooks, and strong rivers rushing over the blue slopes which are reflected in the transparent dark lakes. High up among these lie the prettily poised dwellings of the men, like eagles' nests stuck to the rocks. To make the similarity with the Swiss Alps complete, the green meadows are also not wanting in Scandinavia; and, while the northern mountains do not resound with the exultant jodel, joyous, fresh, melodious songs may be heard in the valleys and on the heights. The difference between Switzerland and Scandinavia is nevertheless great, even if we only consider how the deep sea cuts into the land and forms large bays which receive, from the shadows thrown upon them by the dark surrounding rocks, a mysterious yet not fearful aspect.

The fiords of Norway are remarkable, but they are not the most peculiar feature of the country; this is found in the innumerable islands which rise more than a thousand metres above the sea, or, planting their roots in the boundless deep, are visible only at low water. These islands are charming in the highest degree, and their peculiar beauty approves itself when the sun is resting below the horizon at midnight, and only a breath of twilight sweeps over the masses overflowed by the water. One might then well believe himself in a scene of enchantment.

The farther the traveler advances beyond the polar circle toward the north, the larger and more comfortable are the houses, while in the south, where the population is denser, they are of slighter construction. Yet no furrow is turned, no scythe is swung there; the sea is the field from which man derives his living. At the parting of

day and night, when the sun goes away for months, the men sail recklessly in their boats and canoes to their anchoring-places far up in the north, and their spacious houses are quickly filled with guests. Obeying the resistless drift, come hosts of fishes out of the deepest deeps of the sea, so that the net cast for them mocks the strength of the Herculean men, or is torn under the burden. The throng of the foolish fish is so dense that an oar pushed perpendicularly through it remains upright. Millions are caught, and millions go on, so that there is no sign of a decrease in the number. This migration of the fishes reaches its extreme point at about Christmas-time. No pencil could reproduce the picture which the polar sea exhibits at this season. Hundreds of craft, manned with stalwart fishers, are being incessantly filled with speckled prey; as far as the eye can reach, nothing but fish, which crowd and press upon one another to get to the breeding-place; the massive glaciers and rock-built shores in the background, and, as illuminants to the scene, the ghostly moon and the crackling northern lights. All this time there is also twilight on the southern horizon, and toward February a narrow strip of the sun shows itself again, gradually to rise higher. With the first appearance of day the fishes begin to sink slowly in the fathomless depths. As the sky becomes brighter, the sea and its bays become more quiet. The boats cease to glide over the surface of the waters, the fishermen go home with their spoil, and the northern world lies silent, basking in the beams of the returning sun. But this quiet only lasts for a few weeks, when new noisy, swarming hosts come to the islands. They are the birds, which come up from the sea to the land. It is a deeply poetic trait in the lives of these creatures that only two causes determine them to seek *terra firma*—the power of love and the approach of death. The sea-bird, weather-proof, lives on the sea. He hunts his food by diving, swinging over the billows, and sleeps and dreams with his head hidden under his wings. But there comes a time when the earlier sunbeams kiss the northern islands; then he is mightily moved in his soul, and hastens to the coast to celebrate there his annual wedding. And, when he feels that death is near, he swims with his feeble limbs back to the place of his birth, there to close his life. It is the same feeling that inspires in aged men that ardent desire to return to their old home to die and be buried there. To the naturalist who goes to the north to study the ways of the birds this trait in their character is of peculiar interest. Of one of the tribes of these colonists of the northern bird-mountain I must make particular mention. It is the eider-duck, the producer of down. It belongs to the family of the ducks, and forms, so far as bodily stature is concerned, one of the largest species of the group. The plumage of the male is handsome and brilliant. In it black, red, ashen-gray, ice-green, white, brown, and yellow are mingled with splendid effect. His head and back are snow-white, his neck is rose-red, and the lower part of his body is deep black. The

female is less richly colored, in a modest garment adorned with gray and black spots and stripes. The eider-duck is a real sea-bird, and is excelled by none of its fellows in diving, while no other bird is more awkward in flying and helpless in walking. On the ground it moves with a toilsome waddle, stumbles and falls flat; and it greatly prefers the fluid element to the solid land. The birds generally live during the winter in large flocks on the open sea, and feed themselves with shell-fish which they bring up from the bottom. But, as soon as the spring sun begins to shine over the waves, the drake feels newly awakened the old love in his heart for his mate, and he renews his wooing. One pair after another leave the host and swim steadily toward the land. This wedding-journey toward the breeding-place offers a pretty picture of conjugal life. From the moment when the pair have found one another again there rules only one will, that of the duck, to which the male yields fully and without any wavering. Quite noticeable are his courteous attention and tenderness toward his spouse, which Madame Duck takes, as matters of course, in calm dignity. She steadily makes toward the shore, and finally lands, hardly heeding the cautions of her mate, whose instinct, sharpened by the experiences of former journeys he may have made, prompts him to beware of the devices of men. Loyally he waddles into the country, and follows her in her interminable tours while she is looking for a suitable nesting-place. Madame shows an exceedingly dainty taste during her explorations, carefully examining every bush, shrub, stone, and protected spot, venturing without fear into the dwelling-houses, even into the kitchens and chambers, where, if she finds a spot to her taste, she does not hesitate to take possession of it. Occasionally she will fix her nest in the oven, leaving it to the worthy matron of the establishment to find another place to bake her bread. The thrift of the woman generally gets the better of her vexation, and she lets the fowl alone so as not to lose its down. The nest is quickly built. The foundation is laid with dry grass and straw, after which the duck strips herself of down and forms with it a thickly soft-cushioned bowl. The drake follows every step of his mistress during these excursions and preparations, and looks out for her safety, without, however, "lending a hand" in any of her labors. As soon as the eggs are laid he deserts nest and mate and flies off to the sea to join the other males again. Great throngs of these grass-widowers may then be seen sailing among the islands, wholly unconcerned about what is going on on the mainland. But we shall see how soon they are driven from this careless life.

The duck lays from four to eight, sometimes indeed ten grayish-green eggs, and then begins to sit upon them. The Northmen have been only waiting for this time to gather their spoil. Thirty ducks' nests furnish a pound of down, which can be sold on the spot for thirty marks German or $7.50 American money. The eggs are also worth money, and are generally sent to England. A duck-colony of

this kind is a capital, the income from which is all clear gain, for the bird feeds itself and costs nothing. As soon as the eggs are laid the Northman appears with a great basket, into which he puts nest and eggs. The duck is deeply distressed over this unrighteous seizure of her property, and in her inexpressible agony flies out to sea to seek comfort with her mate. Whether he receives her with tender expressions of sympathy or with scoldings for her neglect of his warnings is still an unsolved problem; but it is certain that he becomes tender again toward her, and after a few weeks waddles back behind her to the same bay where she had been so badly treated. She again gathers straw and grass for the new nest; but how about its warm lining? The new down has not grown upon her in so short a time; what shall she do? There is no mother, not even a duck, that can not find her way out of a difficulty when the question concerns her offspring. Her breast is indeed bare, but her mate still has his full coating of down, and is now obliged to sacrifice it on the altar of affection. He cheerfully adapts himself to the unavoidable, and begins to strip himself. The process does not go on fast enough for the impatient duck, and she helps in the work, and both persevere in it till the drake stands out entirely bald. Then he flies away, and troubles himself no more about wife and nest, an indifference for which we need not blame him in view of his own forlorn condition. The duck herself also thinks of only one thing—her brood. She leaves the nest only once a day for a little while in the morning, to take her bath in the sea, plume herself, and get some food; but while attending to these details she does not forget to cover the eggs carefully with down, so as to keep them warm. Danger no longer threatens the brood from man, who generally takes good care of this hatching to preserve the species; but it is likely to come from birds of prey. Under these circumstances the practical value of the duck's simple duskily speckled coat is fully demonstrated. The color of its plumage agrees so well with that of the ground that it is very hard to distinguish the bird from its surroundings. It has happened to me more than twenty times to be standing directly over a nest and not remark it till I felt a gentle pecking at the feet, which the bird gave me by way of warning that I was approaching too near; for the duck hardly ever thinks of flying from man during the time of its brooding. I have frequently bent down over a nest, stroked the bird, and felt the eggs without its rising. The most it would do was to snap, as if in play, at my fingers.

A characteristic trait of the eider-duck is to have as many eggs as possible, whether they be its own or strange ones; it is a trait that is not found to exist to so great an extent in any other being. The sitting birds steal one from another whenever they have an opportunity. It is no uncommon occurrence, when one of them is away from her nest for a little while, for her neighbor to purloin three or four eggs, carry

them to her nest, and hatch them out with her own. The robbed duck discovers the theft immediately on her return, but gives no sign of concern about it, seeming to say, "We will wait till you go away, and then I shall take my revenge." Her time comes at last; and thus no duck knows whether it is sitting on its own eggs or another's.

The young come out from the eggs at the end of thirty-six days, but do not stay in the nest any longer than till they have become completely dry, when the mother takes them to the sea, which she does not leave till the young have become tired in this their first swimming-lesson, and can no longer ride on the backs of the strong waves. It is usually a considerable distance from the nest to the shore, and the chicks are exposed to many enemies in the shape of hawks, ravens, and gulls, which keep an eager lookout for them. Now the Northman steps in with his protecting hand and comes along with a pair of large baskets, into one of which he puts the young birds and into the other the precious down, while he goes from nest to nest, examining them to see in what ones the brood is ready to be removed. Hence he takes the young ones to the sea, while the mother waddles along behind, well knowing where he is leading her. At the shore he turns the basket over and goes away, leaving it to the old birds to find their own. They plunge into the flock, and each speedily gets as many of the chicks as she can. After a few hours the family bonds are closely sealed again, and each mother has gathered her little ones around her, which she treats with the most tender care, while they in return show the most grateful affection for her. They go with the old ones into the water, crawl around on their backs, and receive instruction in swimming and diving for mussels, the mother in the last exercise going down with a chick under each wing. In the course of eight weeks the young become fully instructed, and are ready to begin the struggle for existence on their own account. Now appears the Herr Papa again upon the scene, when there is nothing more to be done, and proudly conducts the whole company over the open sea to their winter home. Such is the history of the best-known and most interesting of the birds that people the mountains of the North. I have thought it proper to give in brief a clear picture of its habits, because it forms in some respects the central point of the motley, busy company. We will now sketch in broad outline a general picture of one of these bird-mountains.

The storm-gulls are inseparable from the eider-duck. If there are ten thousand pairs of ducks on a mountain, then the number of gulls nesting there will be at least fifty thousand. They come rushing up in graceful, rapid flight, presenting a pleasant aspect with their snow-white and dark-colored feathers. They are the real but innocent betrayers of the eider-colonies, for where gulls circle in great numbers around the island one is sure to find nests of down. The host is further increased by large flocks of a kind of snipe which are distin-

guished by their clear voices. They are the police of the mountain, the guardians of the safety of the bird-republic; for as soon as they perceive anything that betokens danger, say an approaching boat, they cry out in chorus and give an alarm that instantly sets the whole population in motion. The gulls immediately send forth scouts which go toward the boat, soaring, screeching around it, swooping down upon it with the speed of an arrow, and often touching the boatman with the tips of their pinions. The mass of the army follows the scouts. They come by thousands and thousands, in so thick masses as to obscure the sun. The explorer is forced to come to the shore veiled in this living, fluttering, screeching, rushing cloud. The ducks, if they are not actually sitting, fly, the snipes hastily seek the sea, and the wagtails follow in noisy flight, but the host of gulls stands firm, screams and bustles and whirls and plunges, as if it could prevent the advance by noise and sham fighting. One may walk the shore and see nothing but birds and nests, and hear nothing but the discordant din of voices, accompanied by the thunderous rushing of thousands of wings lashing the air.

A more quiet picture is afforded by the hill where the auks brood. They resemble the eider-duck in shape, except that their bills are sharp and not flat, like those of the latter. There are three species of them, which are distinguished from one another by the length of the bill and its curvature. All three species live and brood in the same places. I was told of a mountain where a million of them had built their nests. I am sure of one thing—that no man has ever seen a million birds, even though he has traveled over half the earth. Doubting the accounts, I visited the described mountain. On a bright summer day my companion and myself took a boat and rowed toward it, over the smooth, transparent water, between beautiful islands, followed by the screeching of the startled gulls. High above us on a towering ridge we saw the watchful ospreys; by our side, on right and left, along the shore-cliffs, the sitting eider-ducks. Finally we came to the populous part of the mountain, which is from three hundred and twenty to three hundred and thirty feet high, and saw really immense numbers of birds sitting on the ridges. The higher parts of the cone were covered with a brown spoonwort, and as we approached the shore the birds drew back thither, and suddenly disappeared from view as if by concerted agreement. When we had reached the shore and landed, and were wondering what had become of the hosts of birds, we found the ground burrowed all over with holes that looked like common rabbit-holes. We soon learned that they were the entrances to the nest-chambers of the auks. The holes are large enough to permit the birds to pass through, and then widen on the inside so as to give room for the nest and the two birds. As we climbed toward the height, the tenants first carefully and anxiously peered at us, then slipped out and threw themselves screaming into the sea, which was soon covered, as far as the

eye could reach, with birds whose cry resembled the noise of a gigantic surf or of a raging storm. At last we reached the top of the mountain, where two falcons that had been soaring over our heads swooped down like arrows into the swimming mass; each seized an auk in its claws, and then rose slowly toward the clouds. But the sea extended its wide, dark blue, bare surface before the eye, for the white swarm of birds had disappeared, having dived down beneath the protecting waves. After one or two minutes one arose, then a second, and a third, and so on in quick succession, and, as they thus gradually appeared on the surface, they looked like flecks of white foam. With marvelous rapidity the little dots increased, till soon it was only here and there that a strip of water could be seen. The screeching began anew, and the birds arose again from the water and moved toward the heights. We had sat down; the rustling, like that of the surf, and the monotonous cry of the birds, had lulled us gradually into a deep sleep. When we awoke and opened our eyes we could have believed that we were transported into a fairy land. In numbers like the sand on the sea-shore, the auks were squatting at our feet and down to the edge of the water, and curiously looking at us. We were the giants of the fairy story; they were the dwarfs, who dwelt in the secret caves of the mountain. The millions were there, if one could judge by the eye alone, but it is probable that, on an exact count, they would be many thousands short.

The auk lives a life of strict monogamy. It is to his beloved old wife, the flame of his youth, that he gives his attentions on every returning spring. The old auk is a constant, loving spouse, a pattern of a husband, and it is really a pity that the numerical relation of the sexes is such that not every young male can mate himself, and many are compelled to wander through life in compulsory bachelorhood. Particularly painful is the condition of the solitary one when the pairs go to the mountain in the spring. What shall he do? Shall he alone or with other morose companions wear out his life on the high sea? No, that would be suicide. He follows the bridal trains to the mainland and has at least a happy company around him, and may always hope that one of the males may perish, and he then in some possible way find favor in the eyes of the widow. The auks return every year to their old nests, which they readily distinguish, and the young, newly mated pairs build themselves new nests, or take possession of old ones whose owners have gone the way of all flesh. The male keeps watch at the entrance, while the female sets the house in order and lays her single egg, which is sat upon for about three weeks and a half. The female sits twenty-one hours a day, and the male ought to sit three hours, but he never does it, at least not in the beginning. As soon as the female goes away he rushes after her in a spasm of jealousy, for the young fellows are lurking around in all the corners and at all points. But this neglect of duty by the house-tyrant brings no harm to the

egg. The nearest young fellow nimbly slips into the nest, and keeps the egg suitably warm till the mother returns. Shall he not also have a little satisfaction when others are sipping the joys of life in full draughts? There are no orphans among the auks. If a pair happen to die, the young fellows will hatch the egg out, or, if the chick is already hatched, they will take care of it. The early instruction of the chick is a matter of patience, time, and trouble. As soon as it is dry, the parents take it to a cliff by the sea-shore and spring down, while the young one remains standing above and not knowing what to do in his helpless condition. The old ones call, but he does not follow, for he is afraid of the leap and of the strange element. Father and mother repeat the leap again and again, and encourage the timid one. The young bird follows at last, not venturing upon the leap, but in a kind of desperate mood letting himself fall. As soon as he has touched the swinging wave he feels at home, and begins to swim bravely, the parents keeping by him, so as to give him rest on their backs when he is tired.

A quite different spectacle is presented by those mountains which are principally inhabited by a particular species of gull. To observe one of them I made a special excursion into Lapland. I had at the time a design of writing a book on the life of birds, and had read in some work about three-toed gulls that nested in the bird-mountains in such multitudes "that they darkened the sun when they rose, completely covered the mountain when they sat down upon it, deafened the ears when they screeched, and turned the verdure-clad rocks white where they were sitting." There are only three such mountains known —one in Lapland, one in Iceland, and one in Greenland. The one in Lapland, which is much the most remarkable, lies out of the course of the steamer, and we were therefore obliged to charter a special boat to reach it. A storm compelled us to go into a harbor of refuge. When the tempest had abated, about midnight, we continued our voyage. The waves were still high, and single gulls shot before and around us like dazzling white flashes. All at once, at Cape Svaerholm, not far from the North Strait, there rose before us a great black cliff. It looked like a large marble table covered with millions of little white points that shone like stars. We fired a shot at them, when, as soon as the report had ceased, these became living birds, pure white gulls, and sunk in a few minutes hastily down to the sea in so compact a throng that I might have thought a snow-storm had broken loose and was pouring its immense flakes down from the sky. For a few minutes it snowed birds as far as one could see. The surge rolled wild, but it was the euphonious accompaniment of the rustling of the wings and of the shrieks of the frightened sea-birds. As far as the eye could reach the waves were covered with the foam-born children of the sea, and the cliff and the mountain were as white-dotted as before. Yet these were only the males, which had rushed away on the approach of danger.

# NEUTER INSECTS.

By CHARLES MORRIS.

IN the later editions of Darwin's "Origin of Species" he has answered with remarkable ability nearly all of the several weighty arguments brought against his theory. Some seemingly insuperable objections have been met with an array of facts before which they quite break down. Thus, several instances of extraordinary organs in certain species or types of animals, which it was claimed could not possibly have originated through natural selection, he has shown to be connected by intermediate variations with ordinary organs, which variations are useful at every point of their development, so that the strange appendages might easily have arisen through minute gradations of change.

There is one objection, however, which he can scarcely be said to have answered so happily. This is that in reference to neuter insects —the specially developed working-ants, for instance. As he himself acknowledges, the phenomenon of neuter insects appeared to him at first insuperable, and actually fatal to the whole theory, since these neuters often differ widely in instinct and structure from the males and females, yet, being sterile, they are incapable of hereditarily reproducing their characteristics. In working-ants the difference from the sexual forms is often very great, as in the shape of the thorax, the lack of wings and sometimes of eyes, and in instinct. The difference in instinct is still greater in the hive-bee. Nor is this the whole of the difficulty. In some species of ants there are two and even three distinct castes, well defined, and each with specialities of structure.

Yet, as it is quite impossible that these sterile females could transmit their peculiarities to descendants, and as no such peculiarities exist in the structure of the males and developed females, hereditary influence would seem to vigorously oppose their reproduction, and it seems quite extraordinary that the sexual forms should produce offspring so markedly unlike them. The case is as remarkable as if the offspring of a lion and lioness should be a cat or a leopard, or if a sheep should produce an antelope.

Darwin seeks to explain this difficulty by considering that selection may apply to the family as well as to the individual, and that chance peculiarities of structure, which proved useful to the community, may have been preserved by selection, the tribes in which such useful aberrant forms appeared surviving, while tribes more normal in reproductive power perished. Illustrative facts tending in the same direction are given, and there is certainly a degree of force in this argument, though it can scarcely be accepted as wholly satisfactory.

It is probable that Darwin did not give to this question as full a

consideration as to many others, or his remarkable power of analysis could not have failed to perceive other important bearings of the subject. A full review of the phenomena of larval development certainly seems to remove the mystery of the neuter ant and bee from the position of an anomaly to that of an ordinary method of structural unfoldment. If the appearance of sexual organs and powers is the final step to maturity, then all neuters are larval forms, although in every other respect their development may be complete; and they are subject to the same modifying influences as are all larvæ. It is one of the most common conditions of invertebrate life-development for the unfolding offspring to stop at certain stages of growth, and devote itself for a while to nutrition, ere resuming its course of structural development. Such "resting-stages" are those in which there exist specially favorable conditions of nutrition, or of adaptation of the larval form to the conditions of the food-supply. The most notable instances are those seen in the extraordinary larval forms of some of the Echinodermata, and the little less remarkable larval structure of some of the insects and crustaceans. In certain cases several successive larval forms, each deviating considerably from the normal type of the animal, appear.

Yet these peculiarities of structure have never yet been advanced as stumbling-blocks in the way of natural selection. The caterpillar, for instance, while resembling the moth or butterfly in its more deeplying peculiarities, displays remarkable external deviations, and assumes organs and instincts still more anomalous than those shown by neuter ants. The larval star-fish presents an instance of still stranger anomaly. Only the stomachal region and its immediate surroundings pertain to the type, and all the rest of the structure is accessory. When the development of the star-fish is resumed the new form grows out of this internal region of the body of the bipinnaria, or larval form, whose external parts are discarded as useless, or absorbed as food by the new creature. This is the most aberrant instance of such temporary development known. No trace of the star-fish type can be perceived in its larva. It doubtless exists, but is quite masked by secondary formations. Or it may be that this larva represents an ancestral form of the star-fish, as divergent in character as is the crustacean larva of the barnacle from the mature form.

Yet this explanation of atavism, or temporary check to development at an ancestral form stage, only partly meets the difficulties of the case. There is an unquestionable new adaptation to new circumstances to be explained. Natural selection acts upon all forms which give it sufficient opportunity, without regard to whether they are larval or mature. Let us take for an instance the case of the butterfly. Here the development does not proceed continuously, from the germ to the mature form, as in some insects, but is checked for a considerable period at the caterpillar stage. The active nutrition at this stage seems to act as a check upon development, so that the caterpillar is a form

upon which natural selection has full opportunity to produce its effects. Originally it may have simply rested for a time in the direct line of development, on account of finding abundant food. But, as food conditions changed, new enemies attacked it, or old foes adopted new modes of assault, one of two things was necessary for its survival. It must either lose this resting-stage and develop continuously, or it must become adapted to the new conditions. This rendered necessary changes in instinct and in structure. Where the resting-stage, as in the caterpillar, occupied a very large percentage of the total life-duration, and where the process of adaptation had millions of years for its completion, it is not surprising that structural features often very divergent from the typical form were assumed.

There is little or no reason to doubt that all the peculiarities of larval form are due to the two causes here specified: 1. A temporary check to development at some ancestral stage of the animal's unfoldment. 2. An adaptive modification of structure and habit to meet varying conditions in the environment of this stage of development.

Yet in every such case we meet with a difficulty of the same character as that existing in the case of neuter ants. These secondary adaptations are out of the direct line of the animal's development, and it is a question how they can be hereditarily transmitted. The law of phylogenetic development enables us to understand the appearance of certain embryonal peculiarities of structure which do not exist in the mature form. If development is forced to follow its original line, such ancestral features must necessarily appear, though if the development is very rapid only hints of them are perceptible; or they may become utterly obliterated, so far as our powers of observation can decide. Yet such a principle can not apply to secondary structural features, produced in larval adaptation. The latter are in no sense in the direct ancestral line of development, and it is somewhat remarkable that they are so faithfully reproduced, only to be thrown aside again as the animal resumes its temporarily checked development.

It is very evident, from the facts here cited, that the phylogenetic line is subject to disturbing influences. There is no special reason, in the nature of things, why a developing animal should repeat every stage of its ancestral growth. If never disturbed in its development it would naturally do so, since its original evolution from primeval matter lay in that line, and there has been no force since brought to bear upon it to make it deviate. But where any subsequent force causes deviation, that deviation must become persistent. There can be no possible return to the exact ancestral course. Many such deviations have occurred. Some of them are only apparently such, arising from rapidity of development, and the slurring over of intermediate steps in the line of growth. But many of them are results of subsequent adaptation. Such is the case with many of the peculiarities seen in the unfoldment of the mammalian embryo. It has deviated from

the ancestral line to meet certain special requirements of the situation. It can never return to that line. The mere fact that an ancestor once existed, with certain characteristics, has in itself no controlling force upon the development of the embryo.

The secondary adaptations of larval forms have the same bearing upon development as have peculiar ancestral conditions. They become characteristic steps in the line of development to maturity. The sexually mature animal has passed through them all in its growth from the germ, and conditions of the same character are implanted in its own germs, and must unfold in their development. There is no longer an exact phylogenetic line. Many of the ancestral stages have become greatly modified. To the new developing animals those modified stages of growth are ancestral stages so far as it individually is concerned. Development follows this new line, although it may have become a strangely warped and irregular one, and though at certain stages of growth it may yield peculiar organs or tissues which are discarded as useless, or consumed as nutriment, at later stages. The true line of growth in such cases is restricted to the more deep-lying and important parts of the organism, and though, at certain stages of growth, forces appear which produce a special growth of secondary tissue, this is reabsorbed or discarded when the development is resumed. Marked instances of such discarded tissue are seen in the pupal development of certain insects, and in the case of the star-fish development above referred to.

We have paid some little attention to the characteristics of larval growth for two reasons. Their true bearing on the mystery of evolution has been little attended to, and the above-given hypothesis of explanation has not heretofore been offered, so far as the writer is aware. The second reason is that they bear a much closer relation to the phenomenon of neuter insects than might at first sight appear. The neuter insect has not as yet been looked upon as a resting-stage in the line of full development, and as analogous to the lower stages of larval growth. It has, indeed, a peculiarity of its own, that it fails to attain full development. And as its secondary characteristics are not participated in by the sexually mature form, but have arisen by adaptation which is still operative, the fact of their transmission becomes difficult to understand. Yet we think it may be shown to be but an extension of the principle above considered.

It is a significant fact that a neuter worker class is found only in those animal tribes in which the social principle has reached its highest development, such as the bees, ants, and termites among insects, and the hydroid polyps in the other sub-kingdoms of life. In each of these communal types of life there has been a division of duties, the work of reproduction being confined to one or a few members of the community, at least so far as maternity is concerned, while the other members have gained special adaptations to other duties. In bee com-

munities only one queen is permitted to develop, while the remaining females continue sterile, and become adapted to working duties. Among the ants numerous queens develop, but each surviving queen usually becomes the mother of a separate community, in which the sterile females are adapted to two or more distinct duties. The problem of the males is a singular one. Among bees and ants they are never checked at the worker stage, but develop to become a possible burden on the community. Here among the bees a second remarkable instance of intelligent selection is displayed. The males are suffered to live as long as food is abundant, but are mercilessly stung to death as soon as there is danger of lack of food. In ant communities natural selection disposes of the surplus males. Their life-power is reduced to that required for the nuptial flight, and they die as soon as their one necessary duty is performed.

Among the termites, or white ants, we find an interesting extension of this principle. Here restriction applies to both sexes, the workers and soldiers being immature males and females. Some writers, indeed, hold that they are of no sex, but have been checked in development at the larval stage, before sexual differentiation began. And a male as well as a female survives to start the new community, each nest having its so-called king and queen. In polyp colonies we find the same thing in a less developed stage. Each sexual individual is hermaphrodite, and the king and queen powers exist in a single form. In the *Siphonophora*, or floating hydrozoan colonies, the partly developed forms are adapted to four distinct duties. Some of them become contracting bells, and serve for locomotion; others become stomachal tubes, and digest the food of the colony; others are tentacles, or food-catchers; and others are simply covering or protective pieces; yet in all of them the *Medusa* type can occasionally be recognized.

It may be well to point out here that a similar division of duties exists in all the higher members of the vegetable kingdom. Each tree is a colony, the product of buds arising in a common stem, and is thus closely analogous to a polyp colony. The analogy goes further—there is a division of duties among the members of the tree colony. Some of these members attain full development and become hermaphrodite sexual individuals. The others are restricted in development, and become adapted to several distinct duties. Thus, two distinct nutritive forms appear, the leaf-bearing individual and the root individual. But greatly restricted protective forms occasionally appear, such as the thorn, whose development is on a level with that of the covering-piece in a polyp colony. Other illustrations of this principle of restriction of development and division of duties might be given, but we must go on to consider its significance.

If we consider any of the lower animal forms, it will quickly appear that structural development is checked more or less completely during

active life and abundant nutrition. Insect larvæ, for instance, simply grow during their active feeding-stage. New development only begins during the inactive pupal stage, in which the tissue formed during the larval stage is modified and transformed. After the insect becomes again active, as the imago, no further development of special importance takes place; and it would appear that, if the larval stage is not allowed its full period or its complete course of nutrition, the pupal development is checked at an imperfect stage, and the imago remains immature.

Such is evidently the case in bee communities. The division of the community into males, queen, and workers seems less an operation of natural selection than of intelligent selection. It is a matter of choice among the workers whether any female larva shall develop into a worker or a queen. By giving more room for growth, and more and better food, they can produce a queen from any female larva chosen at will. By contracting the growth-space and diminishing the food, the power of development is checked, and the insect, in its pupal stage, becomes incapable of developing sexual organs and powers.

Thus in every female larva it seems evident that innate powers to become either queen or worker exist. The queen is the higher phase of development, but in attaining this stage the worker stage must be passed through. Why does it not become apparent? This is not difficult to understand, since a similar phenomenon is of very common occurrence. It is simply slurred over in a rapid course of development. The sexual organs begin to unfold, and in so doing exhaust the nutriment and the life-energy which would be needed for the full unfoldment of the worker organs. Thus the superior force checks the inferior, and the innate tendency to develop into a worker is overcome by the activity of a more energetic innate tendency. Where the latter remains aborted the worker tissues fully develop, and with them the worker instincts, since every stage of structural development seems accompanied by its peculiar instincts, as if tissue dominated instinct.

In the case of the ant we have closely similar phenomena. Here there is no satisfactory evidence of intelligent selection, though many observers believe that it exists. So far as we know, however, chance decides whether the larva shall have food enough to carry it to one or other of the worker stages, or to the queen stage. Thus numerous individuals of each stage appear. But the two or more worker castes are not completely separated, since intermediate forms exist, sufficient to make a line of insensible gradation from one form to the other or others. Here, then, we have a complete line of development, reaching from the germ to the queen, but checked at various stages, in which nutrition becomes active and secondary adaptations appear. These secondary adaptive features have undoubtedly become part of the direct line of structural unfoldment. But, as soon as a higher phase of structure begins to unfold, these lower conditions of tissue

are broken down or reabsorbed, just as in the human embryo the gill-arches disappear, or are transformed into organs required in the next higher stage.

If, in the insect pupal stage, the development of the higher structural stage begins simultaneously with, or immediately after, that of a lower stage, the latter is interfered with by a superior energy. It can not obtain full unfoldment, and may gain but a rudimentary formation, which may be immediately reabsorbed, to answer the demands of the superior modifying energy. Two unlike energies seem fighting for the nutriment, and the stronger wins. Instances of this principle of development are common in embryo growth, and act to check or to completely abolish the unfoldment of ancestral features. In the case of the ant we may look upon it as the cause of the lack of appearance of the worker characteristics in the development of the queen, and of their full development where the conditions are such as to prevent the innate powers of sexual unfoldment from coming into play, and to restrict development at a lower level. It need scarcely be added that in the case of these insects the check to development is final. On leaving the pupa-case, they enter upon a life of active nutrition, in which the powers of development already in operation may produce their full results, but in which the latent higher powers are definitely restrained. In all cases of insect development, and doubtless to a certain extent in all animals, a state of passivity is requisite to active transformation of tissue, while simple growth is the prevailing tendency in states of activity and abundant nutrition. In these latter states organic development may proceed, but it is simply the completion of lines of development which began in the passive state. New lines of development do not begin during nutritive activity. Of this principle many illustrations might be given, had we the space here to adduce them.

In the case already cited, of the hydroid polyps, this principle of development yields some remarkable results. In many instances the sexual individuals unfold into the full medusoid type, and leave the colony to enjoy a free life. In others they remain attached to the colony, and are more or less checked in their full development. This check to development is so great, in certain instances, that a mere bud appears, to bear the generative products. Thus the sexual, instead of being the typical form, remains as a formless protrusion of the polyp stem, or the germs may originate in this stem with no form development.

Yet this seeming anomaly is not without its explanation under the above principle. Where free Medusæ are produced, the sexual organs and products do not appear until after full development and freedom from the colony are attained. In the other cases mentioned the generative products appear earlier, and it is probably their appearance that checks further form development. The innate tendency to de-

velop the medusa form is hindered by the early unfoldment of the superior tendency to sexual development, which exhausts the vital energies and absorbs or prevents the formation of other tissue adapted to the lower life-purposes. The needs of this highest life-power tyrannize over all lower powers, and as soon as it appears all other development ceases. In most animals it is the final step, after all lower stages are completed. Here it is occasionally the initial step, and exhausts the developmental powers before any of the lower stages have appeared.

In plants the same principle holds good. Active nutrition checks development, and unfoldment ceases at the leaf or the root stage. For full development, nutrition must be checked; when a partial resting-stage succeeds, higher transformation sets in, and the sexual bud or the flower individual appears. In many cases hints of the leaf stage of development are displayed. In others this stage is completely aborted. Thus the leaf-bearing individual, in its lack of power to reproduce itself, and in its structural and functional differences from the flower individual, is closely analogous to the case of neuter insects as compared with the sexual forms. In plants, also, we have instances of the aborted development of the sexual forms, closely analogous to those seen in the Hydrozoa. Thus, in these remarkable phenomena of development there seems to be a close relation between the tenants of the two great kingdoms of life.

## MASSON'S INTERPRETATION OF CARLYLE.*

THERE is nothing sadder or more painful in the history of literature than that eclipse of the reputation of Thomas Carlyle which resulted from the publication after his death of various books, biographic and autobiographic, which came as a new revelation of the inner life and personality of the great author. Professor Masson, of the University of Edinburgh, was one of his old and intimate friends, and one of his most ardent admirers. It was but natural, therefore, that when the great reaction came, so injurious to Carlyle's reputation, his friend should find himself called upon to say something in vindication of that apparently much-damaged reputation. Professor Masson's two lectures, delivered before the Philosophical Institution of Edinburgh in February of the present year, give an extremely interesting view of Carlyle's character, opinions, and labors, and certainly go far to vindicate him from much of the reproach that fell upon his name through the publications that quickly followed his death. We have

* "Carlyle Personally and in his Writings." Two Edinburgh lectures by David Masson. Macmillan & Co.

no room here to state the case as fully as it is presented in these lectures. Mr. Froude was the official custodian of all the Carlylian documents, and held the great man's reputation in the hollow of his hand. Professor Masson is justly severe upon him (as have also been many others) for his lack of sympathetic discrimination in dealing with the private expressions of his deceased friend, and giving to the public much to which it had no right, which was undoubtedly never intended for publication, and which was an inexcusable outrage upon innocent persons. Mr. Froude was incompetent for his editorial task: though an intimate and life-long friend of Carlyle, he was constitutionally incompetent to understand and do justice to his character. This is well illustrated by the following passage from Professor Masson's first lecture:

"Another cause which has contributed not a little to the unhappy general effect of the nine volumes is the prevailing somberness and lugubriousness of those portions of them which come from Mr. Froude's own pen. In the 'Reminiscences' and the 'Letters and Memorials of Jane Welsh Carlyle' these consist, of course, but of casual editorial notes and explanations; but, in the four volumes of the 'Biography,' they form the text of narrative and comment in which the fragments of documentary material for all the eighty-five years of Carlyle's life are imbedded. Now, wherever Mr. Froude himself thus becomes the narrator or commentator, his mood is too uniformly like that of a man driving a hearse.

"The contrast in this respect between what is from his own pen and much of the documentary material he digests and edits is very remarkable. There is gloom enough, seriousness enough, in the matter of the documents; but they are not all gloomy or serious. They abound with the picturesque, the comic, the startlingly grotesque, or the quaintly pleasant; some of them actually swim in humor, or sparkle with wit. These Mr. Froude faithfully prints, and perhaps relishes; but they do not seem to have any influence on his own gait or countenance in his office of biographer. This is unfortunate. No mind not profoundly in earnest itself could understand Carlyle, or represent him properly to others; but, if ever there was a life that required also some considerable amount of humor in the bystander for correct apprehension and interpretation of its singularities, it was Carlyle's. Those about him that knew him best, always felt that the most proper relation to much that he said and did was to take it humorously or suffuse it with humor; and that he himself had the same feeling and authorized it in others appeared in the frequency, almost the habitual constancy, with which he would check his conscious exaggerations at the last point with some ludicrous touch of self-irony, and would dissolve his fiercest objurgations and tumults of wrath in some sudden phantasy of the sheerly absurd and a burst of uproarious laughter. Without a recollection of this, many a saying of his, many a

little incident of his daily life, is liable even now to misconstruction, or to interpretation out of its just proportions.

"Take for example Mr. Froude's story of Carlyle's behavior in the first days of his wife's severe illness in 1864, from the effects of a cab accident in the streets of London. 'The nerves and muscles,' says Mr. Froude, 'were completely disabled on the side on which she had fallen, and one effect was that the under-jaw had dropped and that she could not close it. Carlyle always disliked an open mouth; he thought it a sign of foolishness. One morning, when the pain was at its worst, he came into her room, and stood looking at her, leaning on the mantelpiece. 'Jane,' he said presently, 'ye had better shut your mouth.' She tried to tell him that she could not. 'Jane,' he began again, 'ye'll find yourself in a more compact and pious frame of mind if ye shut your mouth.' This story Mr. Froude received, he tells us, from Mrs. Carlyle herself; and there is no doubt as to its authenticity. What I am sure of is that Mr. Froude treats it too gravely, or might lead his readers to treat it too gravely, by missing that sense of the pure fun of the thing which was present in Mrs. Carlyle's mind when she remembered it afterward, however provoking it may have been at the moment.

"Insufficient appreciation of the amount of consciously humorous, and mutually admiring, give-and-take of this kind in the married life of the extraordinary pair, both of them so sensitively organized, has had much to do, it seems to me, with that elaborately studied contrast of them and too painful picture of their relations which Mr. Froude has succeeded in impressing upon the public. There were, it is true, passages of discord between them, of temporary jealousy and a sense of injury on one side at least, from causes too deep to be reached by this explanation; but it rubs away many a superficial roughness; and, if Mr. Froude had been more susceptible of humorous suggestions from his subject, he would not, I believe, have found this married life of Carlyle and Jane Welsh so exceptionally a tragedy throughout in comparison with other married lives, and would not have kept up such a uniform strain of dolefulness in his own performance of the part of the chorus. The immense seriousness of Carlyle's own mind and views of things, the apparent prevalence of the dark and dismal in his own action and monologue through the drama, even *required*, I should say, an unusual power of lightsomeness in the chorus, and this not as mere trick for literary relief, but actually for insight, correction, and compensation."

The lecture from which this passage is taken is full of acute insight into the personality of Carlyle, and is extremely interesting as a study in the interpretation of character; but the second lecture on "Carlyle's Literary Life and his Creed" will have such a special interest for the readers of the "Monthly" that we propose to make copious quotations from it.

Professor Masson begins by looking into the causes of the "belatedness" of Carlyle's literary life, or why it was so late before he achieved the success of world-wide recognition. He reminds us that Keats, Shelley, and Byron, who were contemporaries of Carlyle, had blazed into celebrity, finished their careers, and died, while Carlyle was yet an unknown man. Macaulay, who was by five years a younger man, had a brilliant national fame before Carlyle was recognized. "Not till 1837, when Carlyle was in his forty-second year, and had been three years resident in London—or, rather, not till between 1837 and 1840, when he was advancing from his forty-second year to his forty-fifth—did he burst fully upon the public. His 'History of the French Revolution,' published in 1837, began his popularity, not only evoking applauses for itself, but lifting up the unfortunate 'Sartor Resartus' into more friendly recognition." The "Miscellanies" and "Chartism" followed, and in 1840 appeared "Heroes and Hero-Worship," at which time we may assume that Carlyle had reached his full British celebrity.

Professor Masson speculates very suggestively over this phenomenon, calling attention to a profound change that gradually came over Carlyle's work, in which he passes from the superficial phase of *literature about literature* to the graver and deeper problems of human society and human action, and in which the mere *littérateur* is merged in the more serious philosopher.

"The causes of this 'belatedness' of Carlyle's literary life, to use an expression of Milton's, were various. There had, certainly, been no original defect or sluggishness of genius. The young Carlyle who had just completed his classes in Edinburgh University, the young Carlyle drudging at schoolmastering in Kirkcaldy, the young Carlyle of the next few years again walking in the streets of Edinburgh and living by private tutorship and hack-writing, was essentially the same Carlyle that became famous afterward—the same in moodiness, the same in moral magnanimity and integrity, the same in intellectual strength of grasp. One is astonished now by the uniformity of the testimonies of his intimates of those early days to his literary and other powers, the boundlessness of the terms in which they predicted his future distinction. His own early letters are also in the evidence. They are wonderful letters to have been written in the late teens and early twenties of a Scottish student's life, and paint him as even then a tremendous kind of person. As respects Carlyle's 'belatedness,' then, may not the fact that his element was to be *prose* and not *verse* count for something? It would seem as if that peculiar kind of poetic genius which tends to verse as its proper form of expression can always attain to mastery in that form with less of delay and discipline than is required for mastery in prose; and, at all events, the traditions of literature are such that the appearance of a new genius in verse is always more quickly hailed by the public than anything corresponding in

prose. Now, much as Carlyle struggled after the faculty of metrical expression, ease in that faculty had evidently been denied him by Nature, and it was in prose or nothing that he was to manifest his superiority. Nay, in his earliest prose-writings for the press one observes something of the same stiffness, hard effort, and want of fluency that characterize almost all his verse-attempts. This, however, must have been in great part accidental; for we have only to go to some of his private letters, dashed off in his twentieth year or thereabout, to see that he had already acquired his marvelous power of picturesque and eloquent expression, and was master of a swift, firm, and musical style. But, for such a literary career as his was to be, mere gift of expression, however fluent and eloquent, was not enough. It was not enough that he should be able to write fluently and eloquently in a general way, by the exercise of mere natural talent, on any subject that turned up. He had to provide himself amply with *matter*, with systematized knowledge of all sorts, and especially with systematized historical knowledge. Hence the depth and extent of his readings, the range and perseverance of his studies in French, German, Italian, and Spanish, in addition to Latin and English. For writings so full-bodied as those he was to give to the world, it was necessary that he should step into literature as already himself a *polyhistor* or accomplished universal scholar; and, when he did step conspicuously into literature, it was in fact as already such a *polyhistor*.—In connection with which it is worth while to note how completely by that time Carlyle had emancipated himself from the common idea of so many of his literary contemporaries that literature ought to consist in writing about literature. To this day what are the chief subjects of the essays and books continually set forth by our professed authors? Why, the lives and writings of previous authors, the personages and phenomena of the past literary history of the world. We have Homer, Dante, Shakespeare, Milton, Goethe, and the other literary *dii majorum gentium*, over and over again, with descents to as many of the literary *dii minorum gentium* as may be necessary for variety; and the public is thus deluged with an eternal, ever-flowing literature merely about literature. Now, though Carlyle began in this way too—as witness his essays on Jean Paul Richter, on Goethe and *Faust*, on Burns, on German Playwrights, etc.—there were premonitions even then, both in his mode of handling these subjects and in the fact that such essays were interspersed with others of a more general and philosophic kind, that he would not dwell long in the element of mere literary history and æsthetic criticism, or be satisfied with adding his own contributions, however excellent, to the perpetual conversation about 'Shakespeare and the musical glasses.' Accordingly, before he had fully established himself, he had taken final leave of the mere literature about literature, and had moved on into a literature appertaining to human society and human action generally, to war and statesmanship, to poverty and

crime, to the *quicquid agunt homines* in all lands and ages, literature as but one of the interests. As the capacity for this had to be included in his polyhistoric preparation, we have here also perhaps one of the causes of his comparative 'belatedness.' But there was another, and the chief of all. It lies in that fundamental characteristic of Carlyle's literary genius which Goethe had detected as early as 1827. 'It is admirable in Carlyle,' said Goethe to Eckermann in the July of that year, 'that in his judgments of our German authors he has especially in view the mental and moral core as that which is really influential. Carlyle is a *moral* force of great importance; there is in him much for the future, and we can not foresee what he will produce and effect.' Goethe here struck the key-note. It was the depth and strength of the *moral* element in Carlyle's constitution that was to impart to his literary career its extraordinary importance and its special character of originality. Precisely on this account, however—precisely because he was to be no ordinary man of letters, turning out book after book as an artist turns out picture after picture, but a new moral force in the British community and the whole English-speaking community of the world—he had to bide his time. He had to ascertain and reason out his principles; he had to form his creed. When he did burst fully upon the public it was to be not only as the polyhistor, not only as the humorist, not only as the splendid prose-artist, but also—to use a cant phrase which I do not like, though Carlyle himself rather favored it—as the Chelsea Prophet."

"But if Carlyle was slow in his own individual development, so that the success was long postponed, he must be regarded as slower, and still more 'belated,' with regard to the great progress of thought in this century. He belonged to a former age, and lived over into an age for which he was not prepared, and which he could not understand. He was an earnest man—a man, indeed, of great religious seriousness, and preached loyalty to truth as the supreme duty—but he was behind the age in knowing what truth is or how it is to be found. Of science he knew nothing, and could neither enter into its spirit nor employ its methods, nor even accept its great results. He had positive and systematic views which, although vague, he held with such great tenacity that he was disqualified from entering into those larger conceptions of Nature and the universe which pervade modern thought." On the creed and philosophy of Carlyle Professor Masson expatiates as follows:

"No need at this time of day to dilate on the literary merits of Carlyle's works. There they stand on our shelves, as extraordinary an array of volumes for combined solidity and splendor, all the product of one pen, as can be pointed to in the literature of English prose. It is with the *creed* running through the volumes that we are now concerned, that system of ideas by virtue of which Carlyle became, as Goethe predicted he would become, a powerful *moral* force in his gen-

eration, and on account of which his contemporaries styled him latterly the Chelsea Prophet.

"The first name affixed to Carlyle to signify a perception of the difference of his ways of thinking from those of other people was *Mystic*. This was the name given to him long ago in that Edinburgh circle round Jeffrey which he first stirred by his personal peculiarities when he was a resident in Comely Bank, and by his articles on German subjects. He seemed to be the apostle of an unknown something called 'German Mysticism,' and to be trying to found a school of 'English Mystics.' He dallied with the term himself for a while, and even took it with him to London. Intrinsically, however, there could have been no more absurd designation. By the whole cast of his intellect Carlyle was even the reverse of a mystic, constrained as he was always to definiteness of intellectual conception and to optical clearness of representation; and, though he had a kindly eye toward the Mystics, he could make nothing of them except by unmysticizing them—his essay on Novalis, for example, being an unsatisfactory attempt to extract gleams out of the opaque. It was the novelty of Carlyle's principles to those among whom they were first propounded, the strangeness of the objects he tried to bring within their ken, that occasioned the resort to such a misfitting epithet. A far fitter designation would have been *Transcendentalist*. Pardon me if I detain you a little with this word from the scholastic nomenclature and its applicability to Carlyle. It is easy enough to understand, and we have really no other name so suitable for the thing.

"A *Transcendentalist* in philosophy is the very opposite of what we call a *Secularist*. He is the opponent of that system of philosophy which "apprehends no further than this world and squares one's life according," that system of philosophy which regards the visible universe of time, space, and human experience as the sum total of all reality, and existing humanity in the midst of this universe as the topmost thing now in being. Beyond, and around, and even *in* this visible universe, the Transcendentalist holds—this world of sun, moon, and stars, and of the earth and human history in the midst—there is a supernatural world, a world of eternal and infinite mystery, invisible and inconceivable, yet most real, and so interconnected with the ongoings of the visible universe that constant reference to it is the supreme necessity of the human spirit, the highest duty of man, and the indispensable condition of all that is best in the human genius. In this sense Carlyle was a transcendentalist from the very first. He believed in a world of eternal and infinite realities *transcending* our finite world of time, space, sense, experience, and conceivability.

"In the scholastic nomenclature, however, there may be recognized two distinct varieties of Transcendentalism. There is, first, what may be called *Idealistic Transcendentalism* or *Transcendental Idealism*. By this idealistic theory all the apparent universe of known

external realities—sun, moon, stars, rocks, clouds, earth, and human history and tradition—is resolved or reduced into mere present thinkings of your mind or my mind, a mere complex phantasmagory of the present human spirit; and therefore it is through this present human spirit that one has to seek the all-explaining bond of connection between the real world of finite nature and the real and infinite supernatural world. Now, though Carlyle was acquainted with this idealistic theory, had evident likings for it, and now and then favored it with a passing glance of exposition, I can not find that he had ever worked out the theory in all its bearings—an enormously difficult business—or adopted it intimately for his own behoof. He remained to the end what may be called a *Realistic Transcendentalist* or *Transcendental Realist.* By this is meant that he was satisfied to think of the world of space and time, and of all physical and historical realities, as having substantially existed, in its essential fabric at least, very much as we imagine it by an independent tenure from the Infinite, distinct from that of all past or present conceiving minds inserted into it and in traffic with it.

"Here, however, we may note an interesting peculiarity of his special form of Realistic Transcendentalism, which latterly gave him some trouble. Though he talks of 'rude nations,' 'rude times,' etc., and recognized perhaps a certain progress in human conditions and even in the human organism, he seems essentially to have always thought of humanity as a self-contained entity, fully fashioned within itself from the first, and cut off from all its material surroundings and from any priority of material beginnings. Hence his oppugnancy in his latter days to the modern scientific doctrine of evolution as brought into vogue more especially by the reasonings of Darwin. For a transcendentalist of the idealistic sort the doctrine of evolution can have no terrors. If the world of space, time, and history is but a fabrication of our present thinkings, a phantasmagory of the present human spirit, what does it matter how much our present thinkings may change, or how many æons of so-called time and imagined processes and marches of events we may find it necessary to throw into our phantasmagory? For the transcendental realist the difficulty is greater. Though he has the ultimate relief of believing that the entire procession or evolution of things physical as modern science would represent it—from the Universal Nebula on to the dispersed starry immensity, and so to the solar system, our earth as a planet in that system, and the history of that separate earth through the ages of its existence since it became separate—is but one vast forth-putting or manifestation of the inconceivable Absolute, he does not like to think of himself, the paragon of animals, or of the human mind and soul, as in any way really derived from this antecedent physical evolution, and more especially from those nearer portions of it which concern our separate earth and lead from protoplasmic slime, through differentiated bestialism, to a spe-

cial ancestry in the ape. Some transcendental realists do get over the difficulty; but Carlyle never could. In June, 1868, he wrote in his journal as follows:

"'Surely the *speed* with which matters are going on in this supreme province of our affairs is something notable and sadly undeniable in late years. . . . "All descended from gorillas, seemingly." "Sun made by collision of huge masses of planets, asteroids, etc., in the infinite of space." Very possibly, say I. "Then where is the place for a Creator?" The *fool* hath said in his heart there is no God. From the beginning it has been so, is now, and to the end will be so. The *fool* hath said it—he and nobody else; and with dismal results in our days—as in all days; which often makes me sad to think of, coming nearer myself and the end of my life than I ever expected they would do. That of the sun, and his possibly being made in that manner, seemed to me a real triumph of science, indefinitely widening the horizon of our *theological* ideas withal, and awakened a good many thoughts in me when I first heard of it, and gradually perceived that there was actual scientific basis for it—I suppose the finest stroke that "Science," poor creature, has or may have succeeded in making during my time: welcome to me if it be a truth, honorably welcome! But what has it to do with the existence of the Eternal Unnamable?'

"The speculation as to the genesis of the sun and the probable duration of his heat here adverted to by Carlyle with such recognition of its real importance came before him first, I believe, in the form of a paper by Sir William Thomson, of Glasgow, which I had myself the honor of inserting in 'Macmillan's Magazine.' He was much struck with the paper at the time, and often mentioned it to me afterward. It is characteristic that he should have had less objection to this speculation, assigning a definite beginning to the whole solar system, and pointing perhaps to its ultimate collapse and the cessation of all terrestrial life, humanity included, with the extinction of the sun's heat, than to the nearer scientific speculation as to the evolution of species on the earth itself and man's descent from the gorilla. It is as if he found the imagination of a wholesale crash, whether of formation or of annihilation, in the far-back vast of physical immensity, or the far-future vast of the same, more cleanly, and therefore more endurable, than any imagination of a materialistic derivation of the human organism, through the ape and what not, from earthly protoplasmic slime. On the whole, one may say that he lived too late to be able to accept the modern scientific doctrine of evolution and work it into his philosophy, and remained therefore at the last a transcendental realist of the old school. Or perhaps, with the foregoing passage to enlighten us, it might be fairer to say that, whatever conceptions of a cosmic evolution science might bring in, he found them irrelevant to the main matter, and did not care a rush about them in comparison with the

main matter—which was that men should continue to believe that all things had originated in a supreme and infinite eternal, the reality of all realities, and should walk in that belief as their religion.

"One may be a Transcendentalist in philosophy, however, whether of the Idealistic or of the Realistic sort, and yet go through the world calmly and composedly. Not so with Carlyle. Jeffrey's laughing complaint about him in the first days of their acquaintance was that he was always 'so dreadfully in earnest'; and no one can study the records of his early life without seeing what Jeffrey meant. Carlyle's vitality from his youth upward was something enormous. There was nothing sluggish or sleepy or cool in his constitution, and no capacity for being sluggish or sleepy or cool. He was always restlessly awake; to whatever subject he addressed himself, he grasped it, or coiled himself round it, as with muscles all on strain and nerves all a-tingling; and, when he had formed his conclusions, he was vehement in announcing them and aggressive in their propagation. Necessarily this was the case most of all with his conclusions on subjects the greatest and most fundamental. 'Woe to them that are at ease in Zion' was a text quite after his own heart, and which he was fond of applying to those who seemed to him to be sufficiently right in the main in their private ways of thinking on the deepest problems, but not to be sufficiently earnest in fighting for their conclusions and rousing and agitating society to get them accepted. Plato himself, the supreme transcendentalist of antiquity, and to this day unapproached among mankind for the magnificent sweep of clear intellect and the beauty and gorgeousness of poetic expression with which he expounded Transcendentalism once for all to the philosophic world, was in this category with Carlyle. 'He was a gentleman very much at ease in Zion' was Carlyle's definition of him. In fact, with the exception of Shakespeare in Elizabethan England and of Goethe in more recent times, the calm and composed type of character, in matters of sublime concern, was not that which won Carlyle's highest regard.

"Dropping now all terms of scholastic nomenclature, we may say, more simply, that Carlyle went through the world as a fervid Theist. God, the Almighty, the Maker of all—through all the eighty-five years of Carlyle's life, all the seventy of his speech and writing, this was his constant phrase to his fellow-mortals. 'There *is* a God, there *is* a God, there *is* a God'—not even did the Koran of Mohammed fulminate this message more incessantly in the ears, or burn it more glowingly into the hearts, of the previously atheistic Arabs whom the inspired camel-driver sought to rouse, than did the series of Carlyle's writings fulminate it and try to make it blaze in a region and generation where, as he imagined, despite all the contrary appearances of organized churches and myriads of clergy and of pulpits, the canker of atheism was again all but universal. When he avoided the simple name 'God' or 'the Almighty,' and had recourse to those

phrases—'the Immensities,' 'the Eternities,' 'the Silences,' 'the Infinite Unnamable'—which we now think of, perhaps smilingly, as peculiar forms of the Carlylian rhetoric, it was, as he himself tells us, because 'the old Numen' had become as if obsolete to 'the huge idly impious million of writing, preaching, and talking people,' and he would employ any synonyms or verbal shifts by which he could hope to bring back the essential notion. In his latter days, and always in his own pious self-communings, he seems to have preferred the simple old name he had learned from his father and mother, with its heart-thrilling and heart-softening associations."

Professor Masson then enters upon the question of Carlyle's relation to Christianity, which is too fully treated for insertion here. The curious reader is referred to the discussion itself, which is remarkably interesting. Professor Masson distinguishes between the *Ethic*, or the moral code of Christianity, and its *Metaphysic*, or body of supernaturally derived beliefs. Carlyle accepted the former, but rejected the latter, which, Professor Masson argues, is after all the essential and distinguishing attribute of Christianity. On this point he thus reasons:

"The *ethic* without this *metaphysic* may call itself Christianity, but is not, I hold, Christianity in any sense worth so special a name. To tell men, however earnestly, not to tell lies, not to commit fraud, to be temperate, honest, truthful, merciful, even to be humble, pious, and God-fearing, is very good gospel; but it did not require the events of Judea, as Christian theology interprets them, to bring *that* gospel into the world. The modern preacher who sermonizes always on the ethic and omits the accompanying metaphysic may sophisticate himself into a belief that he is preaching Christianity, but is preaching no such thing. Wherever Christianity has been of real effect in the world, and has made real way for its own ethic, it has been by its metaphysic—that set of doctrines respecting things supernatural which was to the Jews a stumbling-block and to the Greeks foolishness. Now, as Carlyle had wholly given up the metaphysic of Christianity, he can not be classed among the Christians, and thought it honest to avow that he could not be so classed. Indeed, more and more, his attitude toward Christian theology in any of its known and orthodox forms settled into positive antipathy, till at last he declared it to be inconceivable to him that any man of real intellect could be found in that camp without something of conscious insincerity, and looked askance, therefore, on even such ecclesiastical friends of his own as Bishop Thirlwall and Bishop Wilberforce. This feeling found vent in such violent phrases as *shovel-hattedness*, *the Jew-God*, etc.; and he had even been so daring as to project a book or pamphlet to be called 'Exodus from Houndsditch,' the purport of which was to be that people ought universally, as fast as they could, to come out of the land and atmosphere of all Jewish forms and traditions, older or later, only tak-

ing care to pack up what was really their own and bring *that* along with them."

The scientific deficiency of Carlyle's mind was nowhere displayed more strikingly than in his scornful rejection of what science has accomplished in the very fields which he himself cultivated—i. e., the phenomena of human and social affairs. Political economy, as is well known, was his abomination. He is forever talking of "facts," but forever deriding those who studied them methodically. On this point, Professor Masson observes :

"What was even worse, Carlyle not only refused the trouble of considerations of the merely mechanical kind himself, but regarded too generally with contempt the labors and speculations of others in that region. His impatience of reasoned political science in any form, and especially in the form of that modern political economy which he derided as 'the dismal science,' really shut him out, more than he was himself aware, from that intimacy with the 'fact of things' which he defined so energetically as the all-essential necessity for men of all sorts and the sole attainable wisdom. It is by science only, by reasoned investigation only, that we can know, in any department, what *is* the real 'fact of things'; and till we know, from the teachings of strict political science, whether in its present form of so-called political economy, or in some larger and better form, all that we can know of the real 'fact of things' in that department, our practical efforts in politics and philanthropy will continue to be, as they have too much been heretofore, mere knocking of our heads against stone walls, mere pourings of water into sieves. Not less in all matters and contemplations, physical and cosmological, must we receive our instructions as to the real 'fact of things' from the sciences thereto appertaining. If science tells us surely and conclusively that such and such was and has been the course of actual physical nature, then we are bound, whether we like it or not, to imagine the past physical course of things precisely in that manner ; and, if we persist in imagining it one whit otherwise, we incur the guilt of opposing the light, and are untrue to the 'fact of things.' Carlyle, as we have seen, acknowledged this ; but it was but a passing acknowledgment. He was too old, his inveteracy in the constitutional faiths of his own spirit was too confirmed, to permit him to adjust these faiths to the new cosmological conceptions which science was making imperative in his later days, or even to perceive that it was of any great consequence that this should be done."

# RELATIONS OF SCIENCE TO THE PUBLIC WEAL.*

By Sir LYON PLAYFAIR, K. C. B., M. P., F. R. S.

PART SECOND.

V SCIENCE AND INDUSTRY.—In the popular mind the value of science is measured by its applications to the useful purposes of life. It is no doubt true that science wears a beautiful aspect when she confers practical benefits upon man. But truer relations of science to industry are implied in Greek mythology. Vulcan, the god of industry, wooed science, in the form of Minerva, with a passionate love, but the chaste goddess never married, although she conferred upon mankind nearly as many arts as Prometheus, who, like other inventors, saw civilization progressing by their use while he lay groaning in want on Mount Caucasus. The rapid development of industry in modern days depends on the applications of scientific knowledge, while its slower growth in former times was due to experiments being made by trial and error in order to gratify the needs of man. Then an experiment was less a questioning of Nature than an exercise on the mind of the experimentalist. For a true questioning of Nature only arises when intellectual conceptions of the causes of phenomena attach themselves to ascertained facts as well as to their natural environments. Much real science had at one time accumulated in Egypt, Greece, Rome, and Arabia, though it became obscured by the intellectual darkness which spread over Europe like a pall for many centuries. The mental results of Greek science, filtered through the Romans and Arabians, gradually fertilized the soil of Europe. Even in ages which are deemed to be dark and unprolific, substantial though slow progress was made. By the end of the fifteenth century the mathematics of the Alexandrian school had become the possession of Western Europe; Arabic numerals, algebra, trigonometry, decimal reckoning, and an improved calendar, having been added to its stock of knowledge. The old discoveries of Democritus and Archimedes in physics, and of Hipparchus and Ptolemy in astronomy, were producing their natural developments, though with great slowness. Many manufactures, growing chiefly by experience, and occasionally lightened up by glimmerings of science throughout the prevailing darkness, had arisen before the sixteenth century. A knowledge of the properties of bodies, though scarcely of their relations to each other, came through the labors of the alchemists, who had a mighty impulse to work, for by the philosopher's stone, often not larger than half a rape-

* Inaugural address of the President of the British Association for the Advancement of Science, at the Aberdeen meeting, September 9, 1885.

seed, they hoped to attain the three sensuous conditions of human enjoyment, gold, health, and immortality. By the end of the fifteenth century many important manufactures were founded by empirical experiment, with only the uncertain guidance of science. Among these were the compass, printing, paper, gunpowder, guns, watches, forks, knitting-needles, horseshoes, bells, wood-cutting and copper-engraving, wire-drawing, steel, table-glass, spectacles, microscopes, glass mirrors backed by amalgams of tin and lead, windmills, crushing and saw mills. These important manufactures arose from an increased knowledge of facts, around which scientific conceptions were slowly concreting. Aristotle defines this as science when he says, "Art begins when, from a great number of experiences, one general conception is formed which will embrace all similar cases." Such conceptions are formed only when culture develops the human mind and compels it to give a rational account of the world in which man lives, and of the objects in and around it, as well as of the phenomena which govern their action and evolution. Though the accumulation of facts is indispensable to the growth of science, a thousand facts are of less value to human progress than is a single one when it is scientifically comprehended, for it then becomes generalized in all similar cases. Isolated facts may be viewed as the dust of science. The dust which floats in the atmosphere is to the common observer mere incoherent matter in a wrong place, while to the man of science it is all-important when the rays of heat and light act upon its floating particles. It is by them that clouds and rains are influenced; it is by their selective influence on the solar waves that the blue of the heavens and the beauteous colors of the sky glorify all Nature. So, also, ascertained though isolated facts, forming the dust of science, become the reflecting media of the light of knowledge, and cause all Nature to assume a new aspect. It is with the light of knowledge that we are enabled to question Nature through direct experiment. The hypothesis or theory which induces us to put the experimental question may be right or wrong; still, *prudens questio dimidium scientiæ est*—it is half-way to knowledge when you know what you have to inquire. Davy described hypothesis as the mere scaffolding of science, useful to build up true knowledge, but capable of being put up or taken down at pleasure. Undoubtedly a theory is only temporary, and the reason is, as Bacon has said, that the man of science "loveth truth more than his theory." The changing theories which the world despises are the leaves of the tree of science drawing nutriment to the parent stems, and enabling it to put forth new branches and to produce fruit; and, though the leaves fall and decay, the very products of decay nourish the roots of the tree and reappear in the new leaves or theories which succeed.

When the questioning of Nature by intelligent experiment has raised a system of science, then those men who desire to apply it to industrial inventions proceed by the same methods to make rapid

progress in the arts. They also must have means to compel Nature to reveal her secrets. Æneas succeeded in his great enterprise by plucking a golden branch from the tree of science. Armed with this even dread Charon dared not refuse a passage across the Styx; and the gate of the Elysian fields was unbarred when he hung the branch on its portal. Then new aspects of Nature were revealed:

> "Another sun and stars they know
> That shine like ours, but shine below."

It is by carrying such a golden branch from the tree of science that inventors are able to advance the arts. In illustration of how slowly at first and how rapidly afterward science and its applications arise, I will take only two out of thousands of examples which lie ready to my hand. One of the most familiar instances is air, for that surely should have been soon understood if man's unaided senses are sufficient for knowledge. Air has been under the notice of mankind ever since the first man drew his first breath. It meets him at every turn; it fans him with gentle breezes, and it buffets him with storms. And yet it is certain that this familiar object—air—is very imperfectly understood up to the present time. We now know by recent researches that air can be liquefied by pressure and cold; but as a child still looks upon air as nothing, so did man in his early state. A vessel filled with air was deemed to be empty. But man, as soon as he began to speculate, felt the importance of air, and deemed it to be a soul of the world upon which the respiration of man and the godlike quality of fire depended. Yet a really intelligent conception of these two essential conditions to man's existence, respiration and combustion, was not formed till about a century ago (1775). No doubt long before that time there had been abundant speculations regarding air. Anaximenes, five hundred and forty-eight years before Christ, and Diogenes of Apollonia, a century later, studied the properties of air so far as their senses would allow them; so, in fact, did Aristotle. Actual scientific experiments were made on air about the year 1100 by a remarkable Saracen, Alhazen, who ascertained important truths which enabled Galileo, Torricelli, Otto de Guericke, and others at a later period, to discover laws leading to important practical applications. Still there was no intelligent conception as to the composition of air until Priestley in 1774 repeated, with the light of science, an empirical observation which Eck de Sulbach had made three hundred years before upon the union of mercury with an ingredient of air, and the decomposition of this compound by heat. This experiment now proved that the active element in air is oxygen. From that date our knowledge, derived from an intelligent questioning of air by direct experiments, has gone on by leaps and bounds. The air, which mainly consists of nitrogen and oxygen, is now known to contain carbonic acid, ammonia, nitric acid, ozone, besides hosts of living organisms which have a vast influ-

ence for good or evil in the economy of the world. These micro-organisms, the latest contribution to our knowledge of air, perform great analytical functions in organic nature, and are the means of converting much of its potential energy into actual energy. Through their action on dead matter the mutual dependence of plants and animals is secured, so that the air becomes at once the grave of organic death and the cradle of organic life. No doubt the ancients suspected this without being able to prove the dependence. Euripides seems to have seen it deductively when he describes the results of decay:

> "Then that which springs from earth, to earth returns,
> And that which draws its being from the sky
> Rises again up to the skyey height."

The consequences of the progressive discoveries have added largely to our knowledge of life, and have given a marvelous development to the industrial arts. Combustion and respiration govern a wide range of processes. The economical use of fuel, the growth of plants, the food of animals, the processes of husbandry, the maintenance of public health, the origin and cure of disease, the production of alcoholic drinks, the processes of making vinegar and saltpeter—all these and many other kinds of knowledge have been brought under the dominion of law. No doubt animals respired, fuel burned, plants grew, sugar fermented, before we knew how they depended upon air. But, as the knowledge was empirical, it could not be intelligently directed. Now all these processes are ranged in order under a wise economy of Nature, and can be directed to the utilities of life: for it is true, as Swedenborg says, that human "ends always ascend as Nature descends." There is scarcely a large industry in the world which has not received a mighty impulse by the better knowledge of air acquired within a hundred years. If I had time I could show still more strikingly the industrial advantages which have followed from Cavendish's discovery of the composition of water. I wish that I could have done this, because it was Addison who foolishly said, and Paley who as unwisely approved the remark, that "mankind required to know no more about water than the temperature at which it froze and boiled, and the mode of making steam."

When we examine the order of progress in the arts, even before they are illumined by science, their improvements seem to be the resultants of three conditions:

1. The substitution of natural forces for brute animal power, as when Hercules used the waters of the Alpheus to cleanse the Augean stables; or when a Kamchadal of Eastern Asia, who has been three years hollowing out a canoe, finds that he can do it in a few hours by fire.

2. The economy of time, as when a calendering machine produces the same gloss to miles of calico that an African savage gives to a

few inches by rubbing it with the shell of a snail; or the economy of production, as when steel pens, sold when first introduced at one shilling apiece, are now sold at a penny per dozen; or when steel rails, lately costing forty-five pounds per ton, can now be sold at five pounds.

3. Methods of utilizing waste products, or of endowing them with properties which render them of increased value to industry, as when waste scrap-iron and the galls on the oak are converted into ink; or the badly-smelling waste of gas-works is transformed into fragrant essences, brilliant dyes, and fertilizing manure; or when the effete matter of animals or old bones is changed into lucifer-matches.

All three results are often combined when a single end is obtained; at all events, economy of time and production invariably follows when natural forces substitute brute animal force. In industrial progress the sweat of the brow is lessened by the conceptions of the brain. How exultant is the old Greek poet, Antipater,* when women are relieved of the drudgery of turning the grindstones for the daily supply of corn! "Woman! you who have hitherto had to grind corn, let your arms rest for the future. It is no longer for you that the birds announce by their songs the dawn of the morning. Ceres has ordered the *water-nymphs* to move the heavy millstones and perform your labor." Penelope had twelve slaves to grind corn for her small household. During the most prosperous time of Athens it was estimated that there were twenty slaves to each free citizen. Slaves are mere machines, and machines neither invent nor discover. The bondmen of the Jews, the helots of Sparta, the captive slaves of Rome, the serfs of Europe, and uneducated laborers of the present day who are the slaves of ignorance, have added nothing to human progress. But, as natural forces substitute and become cheaper than slave-labor, liberty follows advancing civilization. Machines require educated superintendence. One shoe-factory in Boston by its machines does the work of thirty thousand shoemakers in Paris, who have still to go through the weary drudgery of mechanical labor. The steam-power of the world during the last twenty years has risen from eleven and a half million to twenty-nine million horse-power, or one hundred and fifty-two per cent.

Let me take a single example of how even a petty manufacture improved by the teachings of science affects the comforts and enlarges the resources of mankind. When I was a boy the only way of obtaining a light was by the tinder-box with its quadruple materials, flint and steel, burned rags or tinder, and a sulphur-match. If everything went well, if the box could be found and the air was dry, a light could be obtained in two minutes; but very often the time occupied was much longer, and the process became a great trial to the serenity of temper. The consequence of this was, that a fire or a burning lamp was kept alight through the day. Old Gerard, in his "Herbal," tells

* "Analecta Veterum Græcorum," Epig. 39, vol. ii, p. 119.

us how certain fungi were used to carry fire from one part of the country to the other. The tinder-box long held its position as a great discovery in the arts. The *pyxidicula igniaria* of the Romans appears to have been much the same implement, though a little ruder than the flint and steel which Philip the Good put into the collar of the Golden Fleece in 1429 as a representation of high knowledge in the progress of the arts. It continued to prevail till 1833, when phosphorus-matches were introduced, though I have been amused to find that there are a few venerable ancients in London who still stick to the tinder-box, and for whom a few shops keep a small supply. Phosphorus was no new discovery, for it had been obtained by an Arabian called Bechel in the eighth century. However, it was forgotten, and was rediscovered by Brandt, who made it out of very stinking materials in 1669. Other discoveries had, however, to be made before it could be used for lucifer-matches. The science of combustion was only developed on the discovery of oxygen a century later. Time had to elapse before chemical analysis showed the kind of bodies which could be added to phosphorus so as to make it ignite readily. So it was not till 1833 that matches became a partial success. Intolerably bad they then were, dangerously inflammable, horribly poisonous to the makers, and injurious to the lungs of the consumers. It required another discovery by Schrötter, in 1845, to change poisonous waxy into innocuous red-brick phosphorus in order that these defects might be remedied and to give us the safety-match of the present day. Now, what have these successive discoveries in science done for the nation, in this single manufacture, by an economy of time? If before 1833 we had made the same demands for light that we now do, when we daily consume eight matches per head of the population, the tinder-box could have supplied the demand under the most favorable conditions by an expenditure of one quarter of an hour. The lucifer-match supplies a light in fifteen seconds on each occasion, or in two minutes for the whole day. Putting these differences into a year, the venerable ancient who still sticks to his tinder-box would require to spend ninety hours yearly in the production of light, while the user of lucifer-matches spends twelve hours, so that the latter has an economy of seventy-eight hours yearly, or about ten working days. Measured by cost of production at one shilling and sixpence daily, the economy of time represented in money to our population is twenty-six millions of pounds annually. This is a curious instance of the manner in which science leads to economy of time and wealth even in a small manufacture. In larger industries the economy of time and labor produced by the application of scientific discoveries is beyond all measurement. Thus the discovery of latent heat by Black led to the inventions of Watt, while that of the mechanical equivalent of heat by Joule has been the basis of the progressive improvements in the steam-engine which enables power to be obtained by a consumption of fuel less

than one fourth the amount used twenty years ago. It may be that the engines of Watt and Stephenson will yield in their turn to more economical motors; still, they have already expanded the wealth, resources, and even the territories of England, more than all the battles fought by her soldiers or all the treaties negotiated by her diplomatists.

The coal which has hitherto been the chief source of power probably represents the product of five or six million years during which the sun shone upon the plants of the carboniferous period, and stored up its energy in this convenient form. But we are using this conserved force wastefully and prodigally, for, although horse-power in steam-engines has so largely increased since 1864, two men only now produce what three men did at that date. It is only three hundred years since we became a manufacturing country. According to Professor Dewar, in less than two hundred years more the coal of this country will be wholly exhausted, and in half that time will be difficult to procure. Our not very distant descendants will have to face the problem, What will be the condition of England without coal? The answer to that question depends upon the intellectual development of the nation at that time. The value of the intellectual factor of production is continually increasing, while the values of raw material and fuel are lessening factors. It may be that, when the dreaded time of exhausted fuel has arrived, its importation from other coalfields, such as those of New South Wales, will be so easy and cheap that the increased technical education of our operatives may largely overbalance the disadvantages of increased cost in fuel; but this supposes that future governments in England will have more enlightened views as to the value of science than past governments have possessed.

Industrial applications are but the overflowings of science welling over from the fullness of its measure. Few would ask now, as was constantly done a few years ago, "What is the use of an abstract discovery in science?" Faraday once answered this question by another, "What is the use of a baby?" Yet round that baby center all the hopes and sentiments of its parents, and even the interests of the state, which interferes in its upbringing so as to insure it being a capable citizen. The processes of mind which produce a discovery or an invention are rarely associated in the same person, for, while the discoverer seeks to explain causes and the relations of phenomena, the inventor aims at producing new effects, or at least of obtaining them in a novel and efficient way. In this the inventor may sometimes succeed without much knowledge of science, though his labors are infinitely more productive when he understands the causes of the effects which he desires to produce.

A nation in its industrial progress, when the competition of the world is keen, can not stand still. Three conditions only are possible for it. It may go forward, retrograde, or perish. Its extinction as a great nation follows its neglect of higher education, for, as described

in the proverb of Solomon, "They that hate instruction love death." In sociology, as in biology, there are three states. The first of balance, when things grow neither better nor worse; the second that of elaboration or evolution, as we see it when animals adapt themselves to their environments; and third, that of degeneration, when they rapidly lose the ground they have made. For a nation, a state of balance is only possible in the early stage of its existence, but it is impossible when its environments are constantly changing.

The possession of the raw materials of industry and the existence of a surplus population are important factors for the growth of manufactures in the early history of a nation, but afterward they are bound up with another factor—the application of intellect to their development. England could not be called a manufacturing nation till the Elizabethan age. No doubt coal, iron, and wood were in abundance, though, in the reign of the Plantagenets, they produced little prosperity. Wool was sent to Flanders to be manufactured, for England then stood to Holland as Australia now does to Yorkshire. The political crimes of Spain, from the reign of Ferdinand and Isabella to that of Philip III, destroyed it as a great manufacturing nation, and indirectly led to England taking its position. Spain, through the activity and science of the Arabian intellect, had acquired many important industries. The Moors and the Moriscoes, who had been in Spain for a period as long as from the Norman conquest of this country to the present date, were banished, and with them departed the intellect of Spain. Then the invasion of the Low Countries by Philip II drove the Flemish manufacturers to England, while the French persecution of the Huguenots added new manufacturing experience, and with them came the industries of cotton, wool, and silk. Cotton mixed with linen and wool became freely used, but it was only from 1738 to the end of the century that the inventions of Wyatt, Arkwright, Hargreaves, Compton, and Cartwright started the wonderful modern development. The raw cotton was imported from India or America, but that fact as regards cost was a small factor in comparison with the intellect required to convert it into a utility. Science has in the last hundred years altered altogether the old conditions of industrial competition. She has taught the rigid metals to convey and record our thoughts even to the most distant lands, and, within less limits, to reproduce our speech. This marvelous application of electricity has diminished the cares and responsibilities of governments, while it has at the same time altered the whole practice of commerce. To England steam and electricity have been of incalculable advantage. The ocean, which once made the country insular and isolated, is now the very life-blood of England and of the greater England beyond the seas. As in the human body the blood bathes all its parts, and through its traveling corpuscles carries force to all its members, so in the body politic of England and its pelasgic extensions

steam has become the circulatory and electricity the nervous system. The colonies, being young countries, value their raw materials as their chief sources of wealth. When they become older they will discover it is not on these, but on the culture of scientific intellect, that their future prosperity depends. Older nations recognize this as the law of progress more than we do; or, as Jules Simon tersely puts it, "That nation which most educates her people will become the greatest nation, if not to-day, certainly to-morrow." Higher education is the condition of higher prosperity, and the nation which neglects to develop the intellectual factor of production must degenerate, for it can not stand still. If we felt compelled to adopt the test of science given by Comte, that its value must be measured by fecundity, it might be prudent to claim industrial inventions as the immediate fruit of the tree of science, though only fruit which the prolific tree has shed. But the test is untrue in the sense indicated, or rather the fruit, according to the simile of Bacon, is like the golden apples which Aphrodite gave to the suitor of Atalanta, who lagged in his course by stooping to pick them up, and so lost the race. The true cultivators of the tree of science must seek their own reward by seeing it flourish, and let others devote their attention to the possible practical advantages which may result from their labors.

There is, however, one intimate connection between science and industry which I hope will be more intimate as scientific education becomes more prevalent in our schools and universities. Abstract science depends upon the support of men of leisure, either themselves possessing or having provided for them the means of living without entering into the pursuits of active industry. The pursuit of science requires a superfluity of wealth in a community beyond the needs of ordinary life. Such superfluity is also necessary for art, though a picture or a statue is a salable commodity, while an abstract discovery in science has no immediate or, as regards the discoverer, proximate commercial value. In Greece, when philosophical and scientific speculation was at its highest point, and when education was conducted in its own vernacular and not through dead languages, science, industry, and commerce were actively prosperous. Corinth carried on the manufactures of Birmingham and Sheffield, while Athens combined those of Leeds, Staffordshire, and London, for it had woolen manufactures, potteries, gold and silver work, as well as ship-building. Their philosophers were the sons of burghers, and sometimes carried on the trades of their fathers. Thales was a traveling oil-merchant, who brought back science as well as oil from Egypt. Solon and his great descendant, Plato, as well as Zeno, were men of commerce. Socrates was a stone-mason; Thucydides a gold-miner; Aristotle kept a druggist's shop until Alexander endowed him with the wealth of Asia. All but Socrates had a superfluity of wealth, and he was supported by that of others. Now, if our universities and schools created that love

of science which a broad education would surely inspire, our men of riches and leisure who advance the boundaries of scientific knowledge could not be counted on the fingers as they now are, when we think of Boyle, Cavendish, Napier, Lyell, Murchison, and Darwin, but would be as numerous as our statesmen and orators. Statesmen, without a following of the people who share their views and back their work, would be feeble indeed. But, while England has never lacked leaders in science, they have too few followers to risk a rapid march. We might create an army to support our generals in science, as Germany has done, and as France is now doing, if education in this country would only mold itself to the needs of a scientific age. It is with this feeling that Horace Mann wrote: "The action of the mind is like the action of fire: one billet of wood will hardly burn alone, though as dry as the sun and northwest wind can make it, and though placed in a current of air; ten such billets will burn well together, but a hundred will create a heat fifty times as intense as ten —will make a current of air to fan their own flame, and consume even greenness itself."

VI. Abstract Science the Condition for Progress.—The subject of my address has been the relations of science to the public weal. That is a very old subject to select for the year 1885. I began it by quoting the words of an illustrious prince, the consort of our Queen, who addressed us on the same subject from this platform twenty-six years ago. But he was not the first prince who saw how closely science is bound up with the welfare of states. Ali, the son-in-law of Mohammed, the fourth successor to the caliphate, urged upon his followers that men of science and their disciples give security to human progress. Ali loved to say, "Eminence in science is the highest of honors," and "He dies not who gives life to learning." In addressing you upon texts such as these, my purpose was to show how unwise it is for England to lag in the onward march of science when most other European powers are using the resources of their states to promote higher education and to advance the boundaries of knowledge. English Governments alone fail to grasp the fact that the competition of the world has become a competition in intellect. Much of this indifference is due to our systems of education. I have ill fulfilled my purpose if, in claiming for science a larger share in public education, I have in any way depreciated literature, art, or philosophy, for every subject which adds to culture aids in human development. I only contend that in public education there should be a free play to the scientific faculty, so that the youths who possess it should learn the richness of their possession during the educative process. The same faculties which make a man great in any walk of life—strong love of truth, high imagination tempered by judgment, a vivid memory which can co-ordinate other facts with those under immediate consideration —all these are qualities which the poet, the philosopher, the man of

literature, and the man of science equally require, and should cultivate through all parts of their education as well as in their future careers. My contention is that science should not be practically shut out from the view of a youth while his education is in progress, for the public weal requires that a large number of scientific men should belong to the community. This is necessary because science has impressed its character upon the age in which we live, and, as science is not stationary but progressive, men are required to advance its boundaries, acting as pioneers in the onward march of states. Human progress is so identified with scientific thought, both in its conception and realization, that it seems as if they were alternative terms in the history of civilization. In literature, and even in art, a standard of excellence has been attained which we are content to imitate because we have been unable to surpass. But there is no such standard in science. Formerly, when the dark cloud was being dissipated which had obscured the learning of Greece and Rome, the diffusion of literature or the discovery of lost authors had a marked influence on advancing civilization. Now, a Chrysoloras might teach Greek in the Italian universities without hastening sensibly the onward march of Italy; a Poggio might discover copies of Lucretius and Quintilian without exercising a tithe of the influence on modern life that an invention by Stephenson or Wheatstone would produce. Nevertheless, the divorce of culture and science, which the present state of education in this country tends to produce, is deeply to be deplored, because a cultured intelligence adds greatly to the development of the scientific faculty. My argument is that no amount of learning without science suffices in the present state of the world to put us in a position which will enable England to keep ahead of, or even on a level with foreign nations as regards knowledge and its applications to the utilities of life. Take the example of any man of learning, and see how soon the direct consequences resulting from it disappear in the life of a nation, while the discoveries of a man of science remain productive amid all the shocks of empire. As I am in Aberdeen, I remember that the learned Dutchman Erasmus was introduced to England by the encouragement which he received from Hector Boece, the Principal of King's College in this university. Yet even in the case of Erasmus—who taught Greek at Cambridge, and did so much for the revival of classical literature as well as in the promotion of spiritual freedom—how little has civilization to ascribe to him in comparison with the discoveries of two other Cambridge men, Newton and Cavendish! The discoveries of Newton will influence the destinies of mankind to the end of the world. When he established the laws by which the motions of the great masses of matter in the universe are governed, he conferred an incalculable benefit upon the intellectual development of the human race. No great discovery flashes upon the world at once, and therefore Pope's lines on Newton are only a poetic fancy:

"Nature and Nature's laws lay hid in night;
God said, 'Let Newton be,' and all was light."

No doubt the road upon which he traveled had been long in preparation by other men. The exact observations of Tycho Brahe, coupled with the discoveries of Copernicus, Kepler, and Galileo, had already broken down the authority of Aristotle and weakened that of the Church. But, though the conceptions of the universe were thus broadened, mankind had not yet rid themselves of the idea that the powers of the universe were still regulated by spirits or special providences. Even Kepler moved the planets by spirits, and it took some time to knock these celestial steersmen on the head. Descartes, who really did so much by his writings to force the conclusion that the planetary movements should be dealt with as an ordinary problem in mechanics, looked upon the universe as a machine, the wheels of which were kept in motion by the unceasing exercise of a divine power. Yet such theories were only an attempt to regulate the universe by celestial intelligences like our own, and by standards within our reach. It required the discovery of an all-pervading law, universal throughout all space, to enlarge the thoughts of men, and one which, while it widened the conceptions of the universe, reduced the earth and solar system to true dimensions. It is by the investigation of the finite on all sides that we obtain a higher conception of the infinite:

"Willst du ins Unendliche schreiten,
Geh nur im Endlichen nach allen Seiten."

Ecclesiastical authority had been already undermined by earnest inquirers such as Wycliffe and Huss before Luther shook the pillars of the Vatican. They were removers of abuses, but were confined within the circles of their own beliefs. Newton's discovery cast men's minds into an entirely new mold, and leveled many barriers to human progress. This intellectual result was vastly more important than the practical advantages of the discovery. It is true that navigation and commerce mightily benefited by our better knowledge of the motions of the heavenly bodies. Still, these benefits to humanity are incomparably less in the history of progress than the expansion of the human intellect which followed the withdrawal of the cramps that confined it. Truth was now able to discard authority, and marched forward without hindrance. Before this point was reached, Bruno had been burned, Galileo had abjured, and both Copernicus and Descartes had kept back their writings for fear of offending the Church.

The recent acceptance of evolution in biology has had a like effect in producing a far profounder intellectual change in human thought than any mere impulse of industrial development. Already its application to sociology and education is recognized, but that is of less import to human progress than the broadening of our views of Nature.

Abstract discovery in science is then the true foundation upon

which the superstructure of modern civilization is built; and the man who would take part in it should study science, and, if he can, advance it for its own sake and not for its applications. Ignorance may walk in the path lighted by advancing knowledge, but she is unable to follow when science passes her, for, like the foolish virgin, she has no oil in her lamp.

An established truth in science is like the constitution of an atom in matter—something so fixed in the order of things that it has become independent of further dangers in the struggle for existence. The sum of such truths forms the intellectual treasure which descends to each generation in hereditary succession. Though the discoverer of a new truth is a benefactor to humanity, he can give little to futurity in comparison with the wealth of knowledge which he inherited from the past. We, in our generation, should appreciate and use our great possessions:

"For me your tributary stores combine,
Creation's heir; the world, the world is mine."

[*Concluded.*]

## THE UNIFORMITY OF NATURE.

By THE BISHOP OF CARLISLE.

THE chief interest felt by readers of the reminiscence of a meeting of the Metaphysical Society, contained in the August number of this review, will probably be found in the striking and really remarkable record of the discussion of a difficult subject by such men as we there find, and under such conditions as are there described. Whatever the subject of discussion, such a symposium so felicitously saved from oblivion could not fail to secure attention and much gratitude to the able chiel who took notes and printed it. But in truth the subject discussed is as interesting as the company who discussed it; and to the writer of the present paper has so proved itself, not only on general grounds, but also because the view which seems to him to be chiefly worthy of consideration, as being the most true and the most luminous, does not appear to have presented itself to the mind of any one of the speakers, or at all events not to have been expressed clearly.

The discussion, as reported, labors under the great defect that there was no preliminary attempt to define the meaning of the phrase which formed the subject of the argument. Yet the "unformity of Nature" is an expression which does not carry upon its front one clear meaning, and one clear meaning only, and therefore needs definition if the truth of any proposition supposed to be implied by it is either to

be affirmed or to be denied. In some senses Nature is obviously not uniform. Take the case of the weather: what can have less of the character of uniformity? Take the seasons: and observe the apparently absolute absence of all rule as to the sequence of fruitful and unfruitful years. Take almost any instance of natural phenomena that you please: and the variety, the eccentricity, the lawlessness, will probably be quite as striking as any characteristic which can be described by the word uniformity. Anyhow, in commencing a discussion, we ought to know precisely what the phrase to be discussed means, or at least what it is held to mean by the disputants engaged in the argument.

I observe that one of the interlocutors of the Metaphysical Society, Mr. Walter Bagehot, affirms that experience can not prove the uniformity of Nature, because it is impossible to say what the uniformity of Nature means. If this be so, and I am not just now contradicting the assertion, all serious discussion must be at an end. It is very well to say that, although experience can never prove the absolute uniformity of Nature, it ought to "train us to bring our expectations into something like consistency with the uniformity of Nature." But why should we expect Nature to be uniform, unless we can give some good reason for believing in this uniformity? And why should we trouble ourselves with a principle of uniformity, the meaning of which, by hypothesis, we are unable to assign?

On the other hand, Mr. Ruskin could scarcely hope to carry many of the company with him when he avowed his disbelief in uniformity altogether, and affirmed that if told that the sun had stood still he would reply: "A miracle that the sun stands still? Not at all—I always expected it would." This view of the matter would seem to imply that there is no principle in Nature which can in any way be described as law or uniformity—a conclusion which is opposed to all our knowledge.

In default of a clear definition of the thesis proposed to the Metaphysical Society, the prevailing thought in the minds of the disputants seems to me to have been, how far the belief in abnormal phenomena, commonly spoken of as miraculous, is consistent with such a belief concerning the laws of Nature as scientific men find themselves compelled to hold. The discussion had clearly an underlying theological character: to more than half the disputants (so at least it seems to me) the theological consequences of an alleged uniformity of Nature were the uppermost thought, and the feature of most pressing interest in the argument. It would be well, perhaps, if this theological bearing of the question could be avoided in discussion. We should be more likely to arrive at a conclusion as to what the uniformity of Nature means, and to what extent the principle is true, if we could regard it entirely as a natural question, and one to be answered upon the ordinary grounds of observation and induction: and I ob-

serve that Professor Huxley seems to recognize this view, or rather he regards the principle as one the truth of which is not proved, but which is valuable as a working hypothesis, and all the more valuable because it has never yet failed him. The separation of the principle from theological considerations is, however, practically impossible; we must make up our minds to many a fight upon the frontiers of the natural and the supernatural. Not a few persons believe that the possibility of religious faith, at this epoch of history, depends much upon the conclusions to which they come concerning the laws and operations of Nature; and I will not venture to deny that they who so believe have some reason to give for their belief.

It is in accordance with the statement just now advanced with regard to the close practical connection between the principle of the uniformity of Nature and theology that we find the said principle brought at once to the front in the Bishop of London's recent "Bampton Lectures," entitled "The Relations between Religion and Science." With the general argument and results of these undoubtedly able lectures I shall not here be concerned, but it will be much to my purpose to make a few observations upon what is said in the first of the series concerning the uniformity of Nature.

The earliest occasion upon which the phrase appears is to be found in the following sentence: "It will be admitted that the Supreme Postulate, without which scientific knowledge is impossible, is the Uniformity of Nature." *

Now, a postulate is a proposition which is granted as the basis of an argument, because its truth is conceived to be self-evident; or at all events it is the simplest proposition to which a chain of reasoning can be reduced, and, if it be not granted, all further argument is impossible. Thus, Euclid's first postulate is, that from one point a straight line can be drawn to any other point. But surely it can scarcely be said of the uniformity of Nature that it has anything of this simple and self-evidencing character. The question, moreover, is not whether scientific knowledge be possible or impossible without it; if impossible, so much the worse for scientific knowledge. The question still recurs, Is the principle true? Moreover, can it be averred that scientific knowledge *is* impossible without this postulate? If so, why is it that the principle is not asserted in Newton's "Principia," or Laplace's "Mécanique Céleste," or the various treatises on light, heat, electricity, botany, and what not? Certainly it seems to me extremely doubtful whether the "Supreme Postulate" either is admitted, or ought to be admitted, as the basis of scientific knowledge.

I suspect, however, that the bishop does not intend the word Postulate to be taken in its strict scientific sense; for he illustrates his position by reference to the discovery of the planet Neptune, which resulted from the assumption that the law of gravitation holds uni-

* Page 6.

versally, and that therefore the unexplained errors of Uranus were due to the action of an exterior planet. But this assumption was as different as possible from a postulate: it was only applying in a new way a law which had already been verified in so many and such diverse cases that there was scarcely the shadow of a doubt in the mind of any astronomer that it was, as its ordinary name professes it to be, *universal* throughout the material cosmos.

I am confirmed in this belief by finding the subsequent statement that "the uniformity of Nature is a working hypothesis, and it never can be more"; * which agrees very much with the view propounded by Professor Huxley at the meeting of the Metaphysical Society. But I am not quite sure that this is consistent with a previous passage in the lecture, which runs thus:

> This, then, is the answer to the question. Why do we believe in the uniformity of Nature? We believe in it because we find it so. Millions and millions of observations concur in exhibiting this uniformity. And, the longer our observation of Nature goes on, the greater do we find the extent of it. Things which once seemed irregular are now known to be regular. Things that seemed inexplicable on this hypothesis are now explained. Every day seems to add not merely to the instances, but to the wide-ranging classes of phenomena that come under the rule.†

The truth of which I am not concerned to dispute; but the paragraph gives a very different complexion to the principle of the uniformity of Nature from that which belongs to it, when regarded as a postulate upon which all scientific knowledge depends.

The truth which I think *is* postulated in the case of Nature is that which is involved in the idea of cause and effect. The Bishop of London refers to Hume's famous discussion of this question, and his conclusion that there is nothing more in cause and effect than the notion of invariable sequence. This conclusion has often been controverted, and the Bishop of London refers to the arguments of Kant and of J. S. Mill: it seems to admit of a very simple and irresistible contradiction from the following consideration: It is easy to give instances in which an invariable sequence takes place, and yet the two events which follow each other are obviously *not* connected as cause and effect. Take the case of lightning and thunder: the thunder follows the lightning with invariable sequence, whether we chance to hear it or not, but the two are separate effects of the same cause acting under different conditions; and no rightly instructed person could imagine that one was the effect of the other. Or suppose that you shout, and produce two echoes from two rocks at different distances; these echoes will satisfy the condition of invariable sequence, and yet will manifestly not be related as cause and effect. Or, to put the case more generally, it is quite possible that a cause may produce more than one

* Page 29. † Page 27.

effect; and these effects being invariably connected will, by ignorant people, be regarded as cause and effect, which they will not be. In fact, the reference of one phenomenon to another as its cause, in consequence of invariable sequence, may have the same essential error involved in it as had the classical example of Tenterden Steeple and the Goodwin Sands.

What is necessary in order that one thing shall be regarded as the effect of another, which may be called the cause, is not only that there shall be an invariable sequence, but also that it shall be possible to assert that the one could not take place without the other, or something equivalent. This invisible, impalpable chain between the one thing and the other must be postulated by the human mind: it constitutes the idea of cause; every child knows perfectly well what it is, and the profoundest philosopher does not go far, if at all, beyond the knowledge of the child.

Let me support what I have been saying by a quotation from Whewell's "Philosophy of the Inductive Sciences":

> We see in the world around us a constant succession of causes and effects connected with each other. The laws of this connection we learn in a great measure from experience, by observation of the occurrences which present themselves to our notice, succeeding one another. But in doing this, and in attending to this succession of appearances, of which we are aware by means of our senses, we supply from our mind the idea of cause. This idea, as we have already shown with respect to other ideas, is not derived from experience, but has its origin in the mind itself; is introduced into our experience by the active not by the passive part of our nature.*

And again Dr. Whewell writes:

> That this idea of cause is not derived from experience, we prove (as in former cases) by this consideration: that we can make assertions, involving this idea, which are rigorously necessary and universal; whereas knowledge derived from experience can only be true as far as experience goes, and can never contain in itself any evidence whatever of its necessity. We assert that "every event must have a cause"; and this proposition we know to be true, not only probably and generally, and as far as we can see; but we can not suppose it to be false in any single instance. We are as certain of it as of the truths of arithmetic or geometry.†

Here is a true postulate; and if to the postulate that every event must have a cause we add these postulates, (1) that causes in Nature are always of the same kind and always act in the same way, and (2) that no new causes come into existence, we should go a long way toward making the uniformity of Nature, if not axiomatic, at all events capable of tolerably simple and satisfactory demonstration.

But these latter postulates will perhaps scarcely be universally granted. I understand those disputants, who in the Metaphysical Society's discussion laid so much stress upon the duty of examining

* Vol. i, p. 158. † Page 159.

into the truth of alleged phenomena lying apparently outside the circle of ordinary experience, to have argued that there might be causes of which ordinary physical science takes no account, and that you can not logically deny the occurrence of what may be called conveniently the "supernatural," unless you assert that the causes which are included in what we call Nature exhaust all possible forms of causation. Such an assertion would probably be rash, even if we took into account only the results which may be produced by the action of the human will. But so far as the physical investigator, the scientific discoverer, the man of science in the ordinary sense of the phrase, is concerned, he may consistently say that all causation of a spiritual or supernatural kind is outside his domain. He may say, "I neither affirm nor deny the possibility of events and phenomena which are not according to the ordinary course of Nature. I am content to take what is called the uniformity of Nature as prescribing the limit of my inquiries"; and he may be able to add, with Professor Huxley, that he has never yet found it to fail him. If it should fail him, the result might possibly be similar to that which mathematicians call the failure of Taylor's theorem, and might indicate, not that the theorem was faulty, but that in certain critical cases the ordinary law of the theorem would not apply.*

The discussion which precedes has been longer than I expected, but I could not well shorten it. Hitherto I have been chiefly engaged in what has been offered by others on the subject of the uniformity of Nature; I now proceed to suggest a view which, if it fails to give the reader's mind as much satisfaction as it affords my own, will at least, I trust, be deemed worthy of some consideration.

Strict views concerning the uniformity of Nature appear to me to date from the period when Newton first showed that the motions of the heavenly bodies could be made the subject of mathematical calculations, or rather of dynamical, for I am not speaking of those which are merely empirical. Newton, in fact, founded what we now call physical astronomy. If we look a little back from this period, we find the opinions of men of the most educated class very loose on the subject of Nature and Nature's laws. It is sufficient to refer to Sir Thomas Browne's belief, that intercourse was possible between human creatures and evil spirits,† and Sir Matthew Hale's often-quoted opinions and consequent judicial action in the case of witchcraft. There was much in popular superstition, much even in orthodox religious belief, and perhaps much in the tendencies of the human intellect, to suggest views of Nature which would now present insuperable obstacles to minds even of ordinary powers and proficiency, but which presented no such obstacles in what may be called the pre-sci-

* There are some passages in pp. 217–219 of the Bishop of London's lectures to which I would have referred had space permitted.

† "Religio Medici;" chap. xxx.

entific era of the world's history. Newton, or rather Newton as developed by Laplace and the French school of mathematicians, entirely changed the whole aspect of things. Laplace, with propriety, described his great work by the title of 'Celestial Mechanics': the purpose of the work, which it effected with singular skill, was the reduction of the whole system of the heavens to the condition of an ordinary mechanical problem—a problem, too, having the advantage that the bodies concerned are all moving *in vacuo*, and that therefore there are none of the difficulties of friction, resistance of the air, and the like, which interfere with the easy solution of terrestrial dynamical problems. To the mathematician the solar system is a set of small bodies, which for some purposes may be even regarded as particles, revolving in connection with one much larger and central body, under the action of mutual gravitation according to a certain simple law; while the earth, regarded by itself and with reference to the phenomena of its own revolution, is a rigid, slightly oblate spheroid, the motion of which in given circumstances constitutes one of the prettiest problems of rigid dynamics. It is difficult perhaps for any one, who has not gone through the study pesonally and practically, to conceive how completely to the mind of a mathematician the solar system resolves itself into a problem of bodies in motion *in vacuo*. But, as soon as the mind apprehends the solar system thus, it has found an instance of the uniformity of Nature upon a very large scale. The mathematician who is capable of sclving the problem of the planetary motions, as Laplace and Lagrange solved it, or who knows anything of the motion of a rigid body revolving as the earth revolves, finds himself simply incapable of conceiving of anything but motion, according to fixed law, being found in the solar system; the uniformity of Nature in this department presses itself upon him with a power which he can not resist.

A mathematician, for example, would find himself entirely precluded from sympathizing, in the most distant manner, with the view expressed by Mr. Ruskin at the meeting of the Metaphysical Society. The standing still of the sun, of which Mr. Ruskin speaks so pleasantly, means the stopping of the revolution of the earth, for the motion of the sun is only the earth's revolution; consequently, what is called the standing still of the sun involves tremendous dynamical consequences, an utter disruption of everything upon the earth's surface, a return of chaos, or I know not what. I am not criticising the expression as to the sun standing still, used in the book of Joshua without any attempt at scientific language. What the actual fact was to which the language used refers, and what was the actual phenomenon, I can not undertake to say; but if we adopt the phrase into the language of the nineteenth century, and in that language speak of the news of the sun standing still as a thing which need not surprise us, but which we have rather expected than otherwise, then I

say that to the mathematician the language involves a necessary catastrophe, and that if the sun did stand still, even for a moment, no one would be left to tell the tale.

It is true that all men are not mathematicians, and that it is impossible for a mind which has not studied physical science mathematically fully to estimate the impression of contradiction and impossibility produced upon the mind which has so studied by an allegation of any irregularity in the clock of Nature. Be it observed that the belief in the uniformity of such a phenomenon as the rising of the sun, or of the effect of the moon on the tides, or of such observed facts as precession and nutation, and many others, is to the mathematical physicist something different in kind from that which arises from mere experience. If you say that the sun has risen millions of times already, and therefore will probably, or almost certainly, rise to-morrow, you offer a good presumptive argument; but it is not the argument which chiefly weighs with the man who knows what the rising of the sun means, and what would be the mechanical result of his failing to do so. My belief, however, is, that the feeling of certainty as to natural phenomena, which such men as Laplace felt for the first time in human history, has percolated (so to speak) through the strata of human intelligence until it has become the common property of almost all. The whole aspect of Nature has been changed; and many a man feels a persuasion of the existence of something which may be described as uniformity, and in virtue of which he questions or doubts or denies many things which would have been accepted as possible or probable in the seventeenth century, without knowing or being able to explain upon what his convictions rest.

Hence, according to my view, the uniformity of Nature, instead of being capable of being defended as a postulate, is, so far as it is true, the result of very hard scientific fighting. In the region of celestial mechanics it may be said to have gained absolute sway, because the motions of the heavens resolve themselves into the ordinary laws of mechanics, supplemented by the law of universal gravitation; and from this region there is a very intelligible tendency to extend the assertion of the principle to other departments of scientific investigation. Such extension, however, must be made with caution; even in the solar system itself, the moment we go beyond mechanics, all uniformity appears to vanish. With regard to size, arrangement, density, in fact every element of planetary existence, variety, which defies all kind of classification, not uniformity, is the undoubted order of Nature.

There is a striking paragraph on this subject from the pen of no less a man than Alexander von Humboldt, which it may be well to quote in this connection. After speaking of the absence of all known law connecting the various planetary elements, their magnitudes, densities, etc., he proceeds thus:

We find Mars, though more distant from the Sun than either the Earth or Venus, inferior to them in magnitude; being, indeed, that one of the long-known greater planets which most nearly resembles in size Mercury, the nearest planet to the solar orb. Saturn is less than Jupiter, and yet much larger than Uranus. The zone of the telescopic planets, which are so inconsiderable in point of volume, viewed in the series of distances commencing from the Sun, comes next before Jupiter, the greatest in size of all the planetary bodies; and yet the disks of these small planets (whose apparent diameters scarcely admit of measurement) are less than twice the size of France, Madagascar, or Borneo. Remarkable as is the small density of all the colossal planets which are farthest from the Sun, yet neither in this respect can we recognize any regular succession. Uranus appears to be denser than Saturn; and we find both Venus and Mars less dense than the Earth, which is situated between them. The time of rotation decreases on the whole with increasing solar distance, but yet it is greater in Mars than in the Earth, and in Saturn than in Jupiter. Among all the planets, the elliptic paths of Juno, Pallas, and Mercury have the greatest eccentricity, and Venus and the Earth, which immediately follow each other, have the least, while Mercury and Venus (which are likewise neighbors) present in this respect the same contrast as do the four smaller planets,* whose paths are so closely interwoven. The eccentricities of Juno and Pallas are nearly equal, but are each three times as great as those of Ceres and Vesta.†

I will not prolong the quotation, but will add the following sentences, which contain the result which I wish to enforce:

The planetary system in its relations of absolute magnitude, relative position of the axes, density, time of rotation, and different degrees of eccentricity of the orbits, has to our apprehension nothing more of natural necessity than the relative distribution of land and water on the surface of our globe, the configuration of continents, or the elevation of mountain-chains. No general law in these respects is discoverable, either in the regions of space or in the irregularities of the crust of the earth. They are *facts* of Nature which have arisen out of the conflict of various forces acting under unknown conditions.‡

In other words, from the point of view now under consideration there is no such thing as the uniformity of Nature.

Nevertheless, the instinct of seeking uniformity in other departments, when it has been discovered in one, and that an important department, is not only intelligible but is of the highest value as a help in the pursuit of knowledge. Professor Huxley, as we have seen, describes the principle as a working hypothesis, which has never failed him; and, so regarded, it can lead to no error, and it may lead to the discovery of new truth. If uniformity be wrongly assumed, the results obtained may be erroneous, or they may not; examination and experiment will show which they are; a working hypothesis may always be freely granted to an investigator, but it must not be confounded with a postulate upon which the whole body of science rests.

Let me illustrate the character of a working hypothesis by a second

* This was written when only four asteroids were known. While this article is passing through the press the discovery is announced of the 249th asteroid!

† "Cosmos," vol. i. (Sabine's translation). ‡ Ibid.

reference to the discovery of the planet Neptune. Two working hypotheses were necessary in this case. First, there was the great hypothesis of gravitation according to the Newtonian law. But, secondly, it was necessary for the purpose of the calculation to make some assumption concerning the supposed planet. It was, accordingly, assumed that Bode's empirical law of planetary distances was true, and that, if the planet existed, its distance would be given by this law. The position of the planet was determined by the remarkable calculations of Adams and Leverrier; and what was the result? That the first hypothesis was confirmed, if it needed confirmation, and that the second was exploded, when the distance of Neptune came to be determined by actual observation. Thus a working hypothesis was proved to be false; but no harm was done. Neptune was discovered, though his distance had been wrongly assumed; the working hypothesis had fortunately been near enough to the truth for the purpose in hand, and, having served that purpose, it could be flung away.

But in speaking of a working hypothesis it should be carefully borne in mind that the very epithet *working* indicates limits within which the work must take place. The hypothesis of the uniformity of Nature, being founded upon or suggested by the discovery of uniformity in a certain department, must be carefully confined to similar departments, or, at all events, must be regarded with suspicion if it goes beyond them. We have already seen that if an astronomer, from the uniformity of mechanical action in the solar system, should conclude that there was some kind of uniformity in the configuration and the relations of the elements of the system, he would find himself deceived. Speculations concerning such uniformity are nevertheless very tempting. Kepler, as will be remembered, could not resist them, and got into some quagmires in consequence. But the temptation must be resisted; an assumed uniformity may lead to serious errors, if it goes beyond the strictly physical region to which it belongs.

And this view of the matter leads, as it seems to me, to sound conclusions, with regard to the relation in which the truth of the uniformity of Nature stands to truths, or supposed truths, of a different kind.

Take, for example, the case of alleged apparitions. I imagine that the tendency in the minds of not a few among us is to ignore apparitions utterly and completely. They are supernatural, and that is enough; they do not conform themselves to the recognized laws of mechanics, optics, acoustics, motion. This is a rebound from the old facility in accepting tales of demonology and witchcraft in pre-scientific times, and it has much to say for itself. Nevertheless, it is scarcely philosophical, and is in no wise demanded by the requirements of science and the conditions of scientific progress. A man may be perfectly orthodox in his physical creed, and yet may admit the weight of evidence in favor of certain alleged phenomena which will not square themselves with physics. Such alleged phenomena are not necessarily

in contradiction to physical truth, they lie rather in another plane; they are like two lines or curves in space, which do not meet, and therefore can not cut each other. There are matters of the highest moment which manifestly do lie outside the domain of physical science: the possibility of the continuance of human existence in a spiritual form after the termination of physical life is, beyond contradiction, one of the grandest and most momentous of possibilities, but in the nature of things it lies outside physics. Yet there is nothing absolutely absurd, nothing which contradicts any human instinct, in the supposition of such possibility; consequently, the student of physical science, even if he can not find time or inclination to look into such matters himself, may well have patience with those who can. And he may easily afford to be generous; the field of physical science is grand enough for any ambition, and there is room enough in the wide world both for physical and for psychical research.

In truth, a wide-spread rebellion among some of the most thoughtful of mankind must be the result of any attempt to press the supposed principle of uniformity to the extent of denying all facts and phenomena which do not submit themselves. Religious faith is necessarily conversant with such facts and phenomena; and though even here a familiarity with the conclusions of science may be useful in steadying the mind and fortifying it against superstition, still there are supernatural truths bound up with the Christian creed, toward which it behooves all to bow with respect, and which can not be refuted by any appeal to the uniformity of Nature.

For Nature can only be uniform when the same causes are at work; and to declare an alleged fact to be incredible, on the ground that it does not conform to the natural order of things, can only be reasonable upon the hypothesis that no new influence has been introduced in addition to those which the natural order of things recognizes. But such an influence may be found in the action of will, or of some spiritual energy which does not exist in the ordinary natural order.

For example, it would be unwise absolutely to deny on *a priori* grounds the history of the stigmata of St. Francis of Assisi. There are not wanting examples to show that physical results of a remarkable kind can be produced by abnormal and excessive action of the affections, and feelings, and imagination. Recently recorded cases seem to invest even with a somewhat high probability the alleged experience of St. Francis.

I am not of course committing myself to any opinion as to the spiritual corollaries which may follow from an admission of the reality of the stigmata; one person may say that they have great religious significance, another that they are a curious instance of the physical effect of the imagination. I only argue that they must not be at once brushed away in deference to some supposed law of uniformity.

Still less is it wise to deny the possibility of events, recorded in

the life of one greater than St. Francis, on the like ground. I am not going into the argument concerning the miracles and resurrection of the Lord; but I wish to suggest that if the potency of a divine will be admitted, we have in the case of these events to take account of a power which does not present itself in the discussion of natural phenomena. We may well as philosophers admit, in consideration of the special circumstances of the case, the possibility of these supernatural facts, while prizing the principle of uniformity as a working hypothesis, or as more than this. For in truth even the action of the ordinary human will introduces strange breaches of uniformity into Nature. Conceive some observer endowed with human scientific faculties contemplating this earth of ours in the pre-human period. He sees the continents covered with forests, beasts of all kinds disporting themselves in the same, a great vigor of vegetable and animal life both in the sea and on the dry land. But all is absolutely wild, not a single glimpse anywhere of human purpose and contrivance. Suppose our observer to speculate upon the future of this scene of life and activity by the help of the working hypothesis of the uniformity of Nature, of which we will liberally allow him the use out of the scientific repertory of our own times. Would it be possible that this working hypothesis could present to his view, as a possible future of the globe, anything essentially different from what he could then see? The limits of land and water might have been observed to vary, and further variation might be anticipated; volcanic action would have been seen to be very active, and it might be expected that volcanoes would still be a potent agent; nay, I will even suppose that an observer is keen enough from his observations to deduce the theory of evolution, and so to expect that the flora and fauna which he witnesses are in process of transformation into something higher; but could he possibly, in his happiest moment, and when his genius was highest, ever have conceived or guessed the change which would come upon the globe when man appeared as the head and crown of the creation? It is not that man would be a stronger, or more active, or more crafty beast, than had ever appeared before, but that he would be a new creature altogether; a creature with plans and purposes of his own, capable of saying, "I intend to do this or that, and I will do it"; a creature, in fact, with a will which, joined to an intelligence infinitely higher than anything exhibited before, would enable him to treat the earth as his own, to subdue the powers of Nature, and fashion the earth's surface after his own pleasure; which also would make him a moral agent, and so a creature different in kind from all those which had preceded him. This, however, is not the point upon which I intend to dwell now; what I wish to point out is, that the appearance of man upon the earth would break to fragments any theory which an observer might have formed with the aid of the working hypothesis of the uniformity of Nature. The forests disappear, except so far as man finds them con-

venient; the land is tilled; the rivers are tamed; houses are built; ships float upon the sea; everything is regarded with reference to human comfort, and the will of man has utterly transformed the whole surface of the globe. The uniformity of Nature, as Nature had been known or manifested hitherto, is altogether set aside by the action of the will of man.

These examples may be sufficient, or at all events may help, to show the manner which the hypothesis of the uniformity of Nature must be regarded in order that it may express the truth. For my own part, I have no desire to speak lightly of it, or to despise it as a scientific guide. I have no sympathy with that opinion of Cardinal Newman, quoted by Dr. Ward at the meeting of the Metaphysical Society, to the effect that England would be in a far more hopeful condition if it were more superstitious and more bigoted. When he adds "more disposed to quail beneath the stings of conscience, and to do penance for its sins than it is," I allow that the words may admit of a wholesome meaning; but superstition, if I understand what is meant by the word, is an immeasurably and unutterably evil thing: it is the substitution for truth of that which is not truth; it is something which, from its possible poetical accompaniments, may be tolerable to man, and nevertheless must, as I conceive, be infinitely intolerable to God. But there is no occasion to sigh for a little more superstition, in order to counteract the evils which may arise from a one-sided view of Nature; nor are superstition and bigotry the best guides to true penance: the thing really to be desired is a symmetrical and equal-handed dealing with human and divine knowledge. In the one department, the uniformity of Nature may be accepted as a valuable working hypothesis; in the other, we contemplate God without any hypothesis at all, as the Author and original Cause of Nature, of whose will uniformity and variety are equally and co-ordinately the expression and the means of manifestation to human intelligence.

To sum up the views which I have endeavored to express in this paper: I trace the belief in the principle, described by the phrase "the uniformity of Nature," to the direct and indirect influences of the successful application of mathematics to the physical theory of the solar system. The principle so established may be used as a working hypothesis in physical investigations, so far as it predisposes us to seek for law and order in all parts of creation. But it must not be dealt with as an absolutely true principle, if for no other reason at least for this, that it has not been found practicable to define its meaning with precision. And especially we must take care not to assume it even as an hypothesis, except in cases in which it is quite clear that nothing but physical causes are concerned. Which last consideration should be regarded as a warning that the introduction of the principle into theological questions may very possibly lead to most erroneous conclusions.—*Nineteenth Century.*

# SKETCH OF PROFESSOR ALPHEUS HYATT.

By RALPH S. TARR.

PROFESSOR HYATT was born April 5, 1838, in Washington, D. C. He attended various schools, among them the Maryland Military Academy, then under the direction of Captain Allen, an ex-officer of the regular army, an old-fashioned teacher, and somewhat of a naturalist. He entered the class of 1860 in Yale College, but after the Freshman year he left the institution to travel for a year in Europe. Returning, he entered the Lawrence Scientific School at Cambridge in 1858, where he took the highest degree, under Agassiz, in 1862.

His parents intended that he should become a merchant; but this was not congenial to the youth's natural tastes, and it was considered the next best course for him to study law. After pursuing for nearly two years studies which were distasteful to him, he finally broke away from college and went to Europe. Upon his return he determined to learn engineering. Thinking that a course in geology would be an excellent introduction to this branch, and attracted by the great name of Agassiz, he began to study that science at the Lawrence Scientific School. While at Cambridge, being attracted by a fine collection of Ammonites, he asked permission to study them, and, after graduation, published a monograph upon them. After a period of service as captain in the army he renewed his studies under Agassiz, in a class which included such students, since become eminent naturalists, as A. E. Verrill, A. S. Packard, N. S. Shaler, S. H. Scudder, F. W. Putnam, E. S. Morse, A. Agassiz, Theodore Lyman, J. A. Allen, and A. S. Bickmore. He afterward went to Salem, where Putnam was curator in the Essex Institute, and in 1867 became one of the curators. Morse and Packard afterward came in, and the four founded and for some years edited the "American Naturalist," which is now published in Philadelphia. These same young naturalists were also instrumental, together with officers of the Essex Institute, in founding the Peabody Academy of Sciences at Salem. They formed the first scientific staff, and together planned the museum, in which Professor Hyatt was appointed a curator in 1869. In the year 1871 Professor Hyatt was elected Custodian of the Boston Society of Natural History, and in 1872 he went to Europe, with his family, to finish the studies on Ammonites which he had begun in the Museum of Comparative Zoölogy in 1861. In 1881 he was elected Curator of the Boston Society. In addition to this he is unofficially in charge of the fossil cephalopods of the Museum of Comparative Zoölogy at Cambridge, and is Professor of Zoölogy and Paleontology in the Massachusetts Institute of Technology. He also has a class from Boston University,

and in connection with the Boston Society is manager of the Teachers' School of Science, which was founded in 1870–'71, for the purpose of giving lectures to teachers in Boston and vicinity.

The Society of Naturalists of Eastern United States, founded in 1883, really arose from an idea of Professor Hyatt's that there should be a society representing the practical side of natural history. He communicated his ideas to Professor Clark, of Williams College, who realized the value of the plan; and it was mainly through the executive ability and energy of Professor Clark that the first meeting was called at Springfield. Professor Hyatt was elected first president of the society for a term of two years. In 1869 he was elected Fellow of the American Academy of Arts and Sciences, and in 1875 he became Fellow of the National Academy.

In his scientific researches Professor Hyatt has been exceedingly active. He first published an article upon "Beatrecia," a large and curious fossil first described as a tree, and then successively placed by different authors in all the several classes of Invertebrata, till at last, by another paper of Professor Hyatt's, it has been again shifted to the Protozoa. In 1866 appeared his "Observations on Polyzoa," an article of importance at that time, upon the structure of this curious and beautiful group of fresh-water animals. This was followed, in 1867, by an article upon "Parallelism between Different Stages of Life in Tetrabranchiata," and in 1872 by an important paper upon the "Fossil Cephalopods of the Museum of Comparative Zoölogy." In these and other subsequent pamphlets upon the fossil cephalopods he has steadily endeavored to elaborate a practical demonstration of the theory of evolution, and to illustrate the laws by which this has taken place among the cephalopods. One of his best works is "Revision of North American Poriferæ," the only work on North American commercial sponges, and one which is recognized throughout the world as one of the finest monographs of Porifera ever published. The field was entirely unexplored, and the group one of the hardest in the animal kingdom—so hard, in fact, that few naturalists have ever touched it. In his "Effects of Gravity upon Forms of the Shells of Planorbis," Professor Hyatt shows how important the action of gravity has been in modifying the shape of the shells of Ammonites and other animals, pointing out many cases where it has undoubtedly fundamentally affected the forms of shells and the growth of the parts and organs of the animals, and produced specific and generic modifications. Some of Professor Hyatt's most important theories have been set forth in an extensive paper, entitled "Genesis of Tertiary Species of Planorbis at Steinheim." It covers one hundred pages, quarto, and has nine plates. Professor Hyatt went to Steinheim with the intention of making additional observations and proving Hilgendorf's theory of the evolution of Planorbis, which was then recognized by paleontologists in Europe as the only positive demonstration of the theory of evolution.

He obtained a much larger series of Planorbis than Hilgendorf had, and was obliged to prove that, although there was a general gradation from the flattened species to the spiral, through many intermediate forms, it was not true that the series of species succeeded each other in time, as claimed by Hilgendorf. All the species, in all their curious modifications, were found together in the lower stratum. Theoretically a graded series was traceable; and no doubt the flattened spiral forms were the ancestors of the more conical spiral forms. He also pointed out the marked resemblance between diseased and wounded individuals of a species, and the degraded form and the correlations of these with the transformations taking place in the old age of other and healthier species of the same group. He attributes his result to the use of mechanical methods. The shells were gathered in bags, carefully labeled, from each stratum, taken home, sifted through graded sieves constructed for the purpose, and every specimen, to the number of several hundreds in each bag, was thus necessarily passed through his hands. Professor Richard Owen, the eminent anatomist, Director of the British Museum, has said of this memoir, "It is a model of the mode in which such researches should be conducted." Besides these, Professor Hyatt is the author of many smaller papers upon nearly all subjects relating to natural history, and he has described many new genera of cephalopods.

Professor Hyatt has discovered that evolutionary changes in general were much more rapid in earlier ages than now, and could be compared closely with the isolated cases of very rapid evolution of forms in such limited localities occurring in later times, as at Steinheim. For instance, in the Silurian period there was a continual struggle for better adaptation to the environment. In other Paleozoic ages, also, evolution must have been rapid to have accounted for the observed changes. It must have been particularly rapid immediately after the groups or individuals originated, and thus should be represented as expanding suddenly from their point of origin, like the spokes of an expanded fan. He further believes that evolution of Cephalopoda has taken place both by progression and retrogression, in four branches. From the straight orthoceratic forms all fossil and modern Cephalopoda have descended. To use his own words: "The *efforts* of the Orthoceratite to adapt itself fully to the requirements of a mixed habitat gave the world the Nautiloidea; the *efforts* of the same type to become completely a littoral crawler developed the Ammonoidea. The successive forms of the Belemnoidea arose in the same way; but here the ground-swimming habitat and complete fitness, for that was the object, whereas the Sepoidea represent the highest aims, as well as the highest attainments, of the Orthoceratites, in their surface-swimming and rapacious forms." No better group for the study of evolution is found in fossiliferous beds, for in the shells every step of growth can be traced, and it can be seen that the coiled forms all go through the

orthoceratitic or straight stage, or an approximate form, at an early embryological period. In these shells, too, all varieties, by disease or accident, are clearly shown, and this has led to the well-supported theory brought forth by Professor Hyatt, that much of the evolution of Cephalopods has been directly caused by pathological conditions—accidents or diseases transmitted to successive individuals, until they become firmly established inherited variations, and lead, in the Cretaceous period, to the death of one of the four orders of cephalopods, the Ammonoidea.

Among the subjects upon which Professor Hyatt is at present at work is his "Theory of Cellular Tissues" just published. This contains his theory of the origin of sex, which is one of the most important that he has ever published. It is that the nuclei of cells are both male and female; that gradually in some cells one element, perhaps the male, might predominate, while in others the female would be strongest. Thus we would have the metazoa stage, where the male and female cells are distinct from each other, but still mixed in the same layer. This specialization goes on until in the cœlenterates we find special layers of cells especially adapted to perform the function of male or female elements, and later, in the vertebrates, separate animals represent the separate elements. This theory he supports by many interesting facts. In the same paper he endeavors to show that sponges are intermediate between metazoa and protozoa. It is very well established that the body-cavity which immediately surrounds the stomach of all vertebrates is homologous to the sacs which spring out from the body-cavity of cœlenterates, and Professor Hyatt's theory is that these sacs are homologous to the branching cavities and sacs which spring from the central cavity in sponges, and further that these fundamental structural modifications originated independently in sponges, in cœlenterates, and probably in vertebrates, from ancestors which never possessed any such characteristic.

The most useful work which Professor Hyatt has done, and that for which he deserves much credit, is in connection with popular science-teaching. His way of teaching is original, and intended to inspire the student with a love for natural history, by teaching him to look about for himself and observe what there is to see. His first interview and study with Louis Agassiz had much to do with shaping his course, and formed the basis of his system of teaching. Since this study has had such an important bearing upon his life, we reproduce the account of it in Professor Hyatt's own words. Professor Hyatt says: "He gave me a Pentacrinite, or stone-lily, a rather complex fossil, and told me to study it. This I thought to be easy work, so I took a stroll in the afternoon and thought little of it. Next morning he came up to my table and asked me what I had found. I had never studied from Nature before, and began giving a very general description, saying that it was a fossil petrifaction, etc., and had what appeared

to be the beginning of a stem. When I got to this point, he said, in an impatient tone : 'Stop ! stop ! you don't know anything about it. It is just what I expected. You haven't told me anything that *you* know. Look at it again and tell me something that you see for yourself !' I had faint book remembrances, and had been relying upon these. Taken all aback at this, I began to work. I thought about it all day and dreamed about it at night. Next morning I began to tell him what I had found out, and before I was one quarter through he stopped me, saying, 'That is good ; but,' he added, 'you have not yet told me what I want.' With this he pointed to the side of the room where star-fishes, ophiurians, and sea-urchins were kept, and told me to see what more he wanted. In this blind way, with no further hint, I worked unsuccessfully for a long time ; then I found that I had omitted the most conspicuous point, the star-like appearance. Not knowing whether this was of importance or not, I timidly reported at the next interview this resemblance to the star-fishes, and Professor Agassiz was satisfied. This burned into my mind the most important lesson of my life : how to get real knowledge by observation, and how to use it by comparison and inference." His acquaintance with Darwin, though confined to a few letters and a short personal visit while in England, had also a marked influence on his life, for he saw here the greatest of naturalists living in a simple, unostentatious manner, paying respectful attention to the studies of even comparatively unknown young naturalists, not anxious, above all things, to claim even that which was due him, but to render justice to the researches and ideas of others. This was so contrary to the usual practice of claiming all possible credit for intellectual results that it produced a profound impression upon Professor Hyatt, and it has influenced his life as it has that of many of the existing generation.

In teaching, Professor Hyatt uses books as little as possible ; his lectures, and those which he superintends before the teachers in the Teachers School of Science, are delivered in a novel manner. Noted investigators are chosen to deliver the courses, which cover all branches of the objective sciences, as Professor Hyatt calls them, except astronomy. The idea of the lectures is to fit teachers for teaching elementary sciences in the public schools. In all cases except physical geography it has been found possible to give each member of the audience specimens of the thing described, so that they may follow the lecturer with the objects in hand, and take them away afterward.

In connection with this branch of instruction, the Natural History Society has issued a series of "Guides for Science-Teaching," of which nine have already appeared. They are all prepared under the guidance of Professor Hyatt, and he himself is the author of five, namely, "About Pebbles," "Commercial and other Sponges," "Common Hydroids," "Corals and Echinoderms," "The Oyster, Clam, and other Common Mollusks," and "Worms and Crustaceans." They are all

models of simplicity, and contain a general review of the subject treated. They are intended to give just such accounts as are calculated to inspire the teacher with the truths of nature, and at the same time to teach her the simplest and best way of impressing the facts upon the minds of young pupils. In the introduction to the work on pebbles, the author says: "When properly considered, the essay is a series of suggestions, not an exact, cut and dried process. The memorizing of a single part will spoil the effect of the design. If the older scholar, when the lessons are finished, can not go through with the whole process and show what he has been taught with the specimens, it may be considered as proof that it has been done too quickly for him to fully comprehend each of the various steps by which a pebble is formed." The same plan as the one so successful in the Teachers' School has been suggested for the public schools—that each pupil be supplied with a specimen of the object, and that they be asked in turn to point out its features.

During the first few years after the United States Fish Commission was founded, Professor Hyatt spent his summers at the summer station, being allowed by the kindness of the commissioner to collect specimens to illustrate his lectures. Since then, with but one or two exceptions, his summers have been spent at Annisquam, near Gloucester, Massachusetts, where he can study in quiet seclusion. Previous to 1879 he had been in the habit of allowing a few students from the Institute of Technology to study with him in his private laboratory at Annisquam. Soon, however, the number of applications became too numerous, and he could no longer accommodate all, so that in 1879 steps were taken toward founding a general laboratory of natural history to be situated at Annisquam. Each summer the laboratory has been open under the directorship of Professor Hyatt, assisted by Professor Van Vleck, who has immediate charge of all the work. The laboratory was founded and is supported by the Woman's Educational Society of Boston, and is open to both sexes, investigators and teachers being given the preference. Each year the tables are full, sometimes there being as many as fifteen in the laboratory at a time, including some original investigators. The student is given a specimen, and is told to study it carefully and see as much as he can; then to verify his results by referring to Mr. Van Vleck at first, and then to books chosen by him. Professor Hyatt endears himself to all who study with him by his kindness and the interest which he takes in the individual work of the pupil.

A museum as large as that of the Boston Society of Natural History, under the charge of a man so full of original ideas and having the interest of science-teaching at heart, and, at the same time, having such an experience at home and abroad, must of necessity undergo important changes and become unique in its plan. To show the ideas which Professor Hyatt entertains, we quote from his annual report as

follows: "It is quite possible to so arrange and subsequently conduct a museum that it will be as much more effectual in this way (educational) than any art-gallery or library, as Nature herself is greater and more instructive than any imperfect imitations of her ever set in frames or between the covers of books." In his report for 1882 he says that there have been many requests for reference series for consultation, and he suggests that money be raised for the purpose of placing series of specimens illustrating different natural groups so that they may be handled by those having sufficient interest in the subject. This is an important suggestion, and, if it can be carried out, will greatly raise the educational standard of the Natural History Museum. He also suggests that descriptive catalogues of the museum be issued and distributed at frequent intervals.

In order to render the museum a true guide to the study of natural history, to make it, in fact, a natural system in itself, and to illustrate all the forms in a definite and natural manner, Professor Hyatt has adopted a superior plan of arrangement. Let us take, for example, the mineral and geological collection, which is now nearly completely arranged. First of all, the elements are shown, then the elements which enter into rock formations in an elementary form. Then there is a series of what might be called rock-elements—that is, rocks which are composed of one mineral, such as mica or limestone. We are then prepared for the final stage of rock-mixtures—such as conglomerates, granites, etc. Next are taken up the rocks as they are formed, either sedimentary or igneous, and so on through the whole rock-world, going step by step in a most natural way from the simplest to the most complex, from the elements to their compounds. This is the natural system, and is being adopted in other departments of the museum.

Such is Professor Hyatt's work. He is a scientist in every sense of the word, and holds a high rank among naturalists. Still, he is able to find time to render science popular—a great work, which scientists are not apt to appreciate and which few try to do. It is an important work, and the only way firmly to establish science upon the world; and that small body of men who are so unselfishly devoting their time to this grand work are deserving of far more credit than those who selfishly shut themselves from the rest of the world, and laboriously work away at abstruse problems, which, after they are discovered, are put in such terms as to be unintelligible to the average person. We repeat it, that those who are doing their best to render science popular are doing far more for true science than those who purposely shun such work, and confine themselves to uninteresting and often unimportant problems.

# CORRESPONDENCE.

## A SIGNIFICANT ANALOGY.

*Messrs. Editors:*

WHEN President White wrote his "New Chapters in the Warfare of Science" he could have had no idea that the same issue of your magazine which contained the first chapter on "The Doctrine of Comets" would also contain a striking illustration by another writer of a similar phase of the same conflict which he has so graphically portrayed.

According to Mr. White, the foolish notions and absurd superstitions which prevailed for so many centuries in regard to comets were due to the irregularity of their movements and the indeterminateness of their orbit. As soon as astronomers had calculated the orbit of a comet and foretold the exact time in which it would appear, "a true doctrine of comets" became possible and was accepted, at least, by the mass of intelligent persons.

Perhaps very few of your readers connected this article on comets with the one on "The Metaphysical Society" in your October number. Yet the passages that I am about to cite will, I think, bear me out in holding that, even among the most intelligent men of the present time, the same kind of ignorance of the phenomena under consideration leads to similar erroneous conclusions.

The very interesting discussion on the "Uniformity of Nature," by such representative men as Dr. Ward, Father Dalgairns, Mr. Ruskin, and the Archbishop of Westminster on the one side, and Professor Huxley, Mr. Bagehot, and Sir James Stephen on the other, at last reaches "no less weighty a thinker" than Dr. Martineau. After stating forcibly the philosophical reasons which make a belief in the uniformity of nature absolutely necessary, "so far as nature is purely dynamic and so far as force is measured by reason" (p. 817), he yet declines to accept this when man's mental nature is concerned.

"Doubtless," he says, "it will be replied that, as in the mind of man there is a free spring of force which is as yet undetermined, which is potential and not actual force, so there is behind nature a free spring of force which is as yet undetermined, which is potential and not actual nature—in short, a power above nature and capable of modifying it; in other words, supernatural, and that doctrine I should heartily accept. The uniformity of nature is the uniformity of force, just as the uniformity of reasoning is the uniformity of thought. But just as the indeterminateness of creative will stands behind the determinateness of the orbit of force, so the indeterminateness of creative purpose stands behind the determinateness of the orbit of thought or inference. I hold that man is not wholly immersed in dynamic laws, that, though our physical constitution is subject to them, our mental constitution rises above them into a world where free self-determination is possible" (p. 817). Have we not here, I ask, another case where "irregularity of movement" and "indeterminateness of the orbit" have produced confusion of thought and caused thinkers to regard as "free" that which, so far as we have any positive knowledge at all, we know to be determined. It would not be difficult to show either that the superstition in regard to "Free Will" has done even more harm than the belief that the appearance of comets betokened evil.

President White's article furnishes such an excellent answer to a pithy question put by Dr. Ward near the close of the debate, that I can not forbear to call attention to it. "Is it not better," he asks, "to have a vulgar belief in God than to have a fine susceptibility to scientific methods?" (p. 819).

During the long ages of ignorance and superstition to which Mr. White has called attention there existed what Dr. Ward wants—"a vulgar belief in God," and there was but a very slight "susceptibility to scientific methods." While it can not be said that even now the tendency toward the latter is very strong, or that a vulgar belief in the Deity has disappeared, yet I think it will be generally admitted that there has been some advance toward a recognition of the merits of the scientific method and some alteration in the beliefs about God; and I leave it to any competent and candid person to say which of these times has been the "better" for humanity.

Yours truly, R. M.

*October* 2, 1885.

## CORPORATIONS AND THEIR EMPLOYÉS.

*Messrs. Editors:*

DR. BARNARD'S well-timed paper calling attention to the lack of direction of the sympathy of corporation managers with their employés deserves a more general consideration than it will be likely to receive from them. As one directly interested in the labor problem, I wish to thank him for calling popular attention to the nearest way to mitigate some of the asperities

of the situation, and for his efforts as Secretary of the Baltimore and Ohio Employés Relief Association.

Speaking from a close association with the class of labor he seeks to benefit, it is my belief that both it and the spirit of our people resent a "paternal care and solicitude" while welcoming a "friendly interest," and perhaps even a "guardian's care."

Some of the members of his Association have characterized it as "too paternal," and though it has done and is doing great good, not only for the Baltimore and Ohio employés but among employés generally, as an example of what can be accomplished, it is well to remember that "compulsory provision for their future welfare" excites opposition, and does not educate his "wards" as would a more friendly help.

This is indicated by the Pullman experiment, of which the popular judgment is: that it is not approved by the employés, and is not so successful as to deserve imitation by employers. G. C. HEWETT.

WINIFREDE, WEST VIRGINIA,
*September* 16, 1885.

# EDITOR'S TABLE.

*PRESIDENT LESLEY'S ADDRESS.*

THOSE of our readers who carelessly pass by the recent discourse of Professor Lesley before the American Association for the Advancement of Science without reading it will make a bad mistake. There is not much danger of this, for the address is sufficiently attractive and brilliant to engage general attention. Professor Lesley enforces many wholesome truths upon the students and devotees of science, and maintains a high ideal of the great purpose that should govern scientific pursuits. On these points we can have nothing to add. But there is a bearing of the whole discourse on common education which should not be overlooked. His address, in one of its chief aspects, is a counterblast against "cram" in science—against the mere accumulation of scientific facts—and it is a ringing demand for more persistent and concentrated labor in small and unobtrusive fields of investigation. His plea for what is called "dead-work" in science, as contrasted with more showy performances, is especially effective. But his observations on "the over-accumulation of scientific information" have an application outside the limits of strict research. "The science of learning and the science of knowledge," he says, "are not quite identical; and learning has too often in the case of individuals overwhelmed and smothered to death knowledge. The average human mind, when overstocked with information, acts like a general put in command of an army too large for him to handle. Many a vaulting scientific ambition has been thus disgraced. Nor is this the only danger that we run; for the accumulation of facts in the treasury of the human brain has a natural tendency to breed an intellectual avarice, a passion for the piling up of masses of facts, old and new, regardless of their uses." "Not only the avarice of facts, but of their explanations also, may end in a wealthy poverty of intellect for which there is no cure." "How much we know is not the best question, but how we got what we know." Professor Lesley touches upon the subject of general education from this point of view as follows:

> I do not intend to discuss the subject, to define the quantity and quality of knowledge adequate for the various classes of human society, or to propose any plans for its distribution. All I wish to say about it is, that it seems to me Nature limits both the responsibilities of teachers and the rights of learners more narrowly than is commonly supposed. The parable of the sower is a good reference for explanation. Most of the surface of the globe is good for little else than cattle-ranches or sheep-farms, and the large majority of mankind must in all ages be satisfied with the mere rudiments of learning. What they want is unscholastic wisdom with which to fight the fight of life, and they must win it for themselves. Only a limited num-

ber of persons in any community can acquire wealth of knowledge, and the only thought on which I wish to insist is this: these few must also get it for themselves, and, moreover, must work hard for it.

It is a hackneyed aphorism that there is no royal road to knowledge, although an incredible amount of pains has been taken to make one. Nature in this affair, as usual, has been a good, wise mother to us all; for it is not desirable to make the acquisition of knowledge easy, for the main point in scientific education is to secure the highest activity of the human mind in the pursuit of truth—an activity tried and disciplined by hardship and nourished on hardy fare. The quantity of food is of less importance; everything depends on establishing a good constitutional digestion. The harder the dinner is to chew, the stronger grows the eater. Canned science as a steady diet is as unwholesome for the growing mind as canned fruits and vegetables for the growing body. The wise teacher imitates the method of Nature, who has but one answer for all questions: "Find it out for yourself, and you will then know it better than if I were to tell you beforehand."

The great vice of current education is here squarely hit. As Huxley says, it is "spoon-victuals"; acquisition made easy by elaborate simplification and explanation which leaves wholly out of view the fundamental truth that mental power can only be acquired through the effort of active exercise. This is the supreme requirement, but it is this which is everywhere, and by all pretexts and devices, evaded. We are still in the lesson-learning, print-worshiping stage of education, almost as much as they were when children were taught from the catechism—

> "My book and heart
> Shall never part."

But the true purpose of education, as can never be enough enforced, is not to learn lessons and get explanations from teachers, and to accumulate information, but to develop power in the minds of the young to observe carefully, to reason correctly, and to think independently about the things that are important and vital in the experience of life. The minds of the young require to be cultivated and trained in this kind of activity; but all the mighty apparatus of books, teachers, superintendents, and boards of education, backed by millions of money, instead of leading to this result, *stand in the way of it.* The two methods are incompatible. Listening to explanations and cramming the contents of books are radically antagonistic to thinking things out, and to that self-instruction the sole condition of which is mental effort, and that should be kept in view as the essential thing to be secured in all education of children and youth.

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### *THE EPIDEMIC AT MONTREAL.*

THE terrible pestilence, which, for several months, has been raging in the beautiful city of Montreal, carrying away thousands of its inhabitants, teaches a painful lesson of the malign consequences to a community of ignorance and superstition when strong enough to set at defiance the resources that intelligent experience has furnished to arrest its progress. It is not as if the people had been struck by some new and mysterious disease before which they were powerless. It is not as with the plagues of former ages, when nothing was known that could be done to arrest them. The saddest aspect of the Montreal calamity is not that multitudes have been swept into unripe graves, but that this vast mortality could have been avoided. That small-pox is practically a preventable disease is established; but to what purpose, when all the apparatus of self-defense in a civilized community is completely paralyzed? A comparatively small element of the population, ignorant, prejudiced, and pious, makes a blind and desperate resistance to the only measures that can bring relief; and they resort to penance, invocation of saints, prayers to Heaven, and solemn processions, to arrest the course of contagion, over which these have no more influence than they would have to arrest the course of the St. Lawrence! The chief ravages of the disease have

been confined to that portion of the French Canadians who were unvaccinated; but such has been the passion of religious fanaticism, and the intensity of race-hatred, that this small minority made a fight stubborn enough to defeat all effectual public action. There have been defiance of authority and constant danger of mob violence which have intimidated the controlling officials and so diminished their effectiveness. The authorities in charge of the leading hospital of St. Roche are said to have favored neither vaccination nor sanitation, and such was the inefficient and horrible condition of that old establishment that many advocated burning it down. The efforts to isolate cases of small-pox have been also desperately resisted, and, worst of all, the officials have misled the people as to the progress of the malady, and by inducing a false security have prevented that energetic private action which must be the main reliance in the last resort. A writer in a Montreal newspaper puts this feature of the case very forcibly. He says: "In the prevailing murmuring and complaint by people with their faces turned toward the City Hall, let us say that, had every man and woman in this city done his or her plain duty about small-pox, there would be no small-pox. It is one of the vices of our age, which Montreal manifests in a marked degree, that 'authorities' are expected to do for individuals what individuals should do for themselves. So far as laws or by-laws lead people to imagine that they can properly or safely divest themselves of any part of their personal responsibility, just so far are laws or by-laws only evil. There is a disastrous superstition abroad which leads people to believe in enactments and legislation. These things can not execute themselves, they can only be put into effect by deputies, often listless or ignorant, and nearly always much less interested in the execution of their work than the men who have thoughtlessly handed to them tasks which should never have been deputed. Whoever may be chargeable with the dire calamity upon us, grumbling will do no good now, and, if the reader wishes to aid the officials and other citizens who are busy fighting the plague, let him add himself to the Citizens' Committee. Work will be given him, and in its difficulty and importance he will have little leisure for complaint."

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### *PARTY GOVERNMENT.*

A NEWSPAPER brings us the fragment of a speech by Senator Hawley, in which he ventures for a moment upon the ticklish ground of defending partisanship, or the necessity of two parties. He had been previously glorifying one party—his own—with, of course, the due condemnation of the opposite party. One would suppose that he could spare the utterly wrong political party, and rejoice in its annihilation, so that the right party could have its perfect way; but he says we must have both, and in enforcing this idea he gives expression to the following curious bit of political philosophy: "It would be a lamentable day indeed for this country, or any other enjoying a free government, when it could be said that there were no parties—that lovely time that some long for, when there should not be enough of moral or intellectual life among the people to get up a single difference of opinion upon political affairs."

Senator Hawley seems here to think that the evidence and the measure of "moral or intellectual life" are seen in the power of "getting up differences"; while we have always supposed they were shown rather in the power of reaching agreement. Differences of views and opinions are certainly indicative of want of intelligence on the matters of disagreement; while "moral and intellectual life" is displayed in that activity of inquiry which leads to the attainment and acceptance of truth,

and to consequent agreement. We are here, however, speaking from the scientific point of view, in which agreement in truth is the supreme end; while Senator Hawley is speaking from the political point of view, in which the errors of difference for partisan purposes are the supreme end. Nor would he have the higher step taken which leads to agreement, for that would end partisanship, and, according to his logic, if parties should come to an understanding on political principles, it would be fatal to free government. "Free government," then, depends upon ignorance, and must be destroyed by the progress of knowledge. Senator Hawley is a politician, and with him partisan politics is the end, with its fruits of office and power. Elections and campaigns are his means, and his sole condition of success is to be able to arouse voters to hot political strife. So he wants differences, because men will fight over differences but never over agreements. Differences in politics there certainly are, and must long continue to be: what we object to in Senator Hawley's political philosophy is, he demands that this low partisanship which he so enjoys shall be eternal, and that it would be a "lamentable day" when it comes to an end.

## LITERARY NOTICES.

A TEXT-BOOK OF NURSING. For the Use of Training-Schools, Families, and Private Students. By CLARA S. WEEKS, Graduate of the New York Hospital Training-School; Superintendent of Training-School for Nurses, Paterson, New Jersey. New York: D. Appleton & Co. Pp. 396. Price, $1.

MISS WEEKS'S "Text-Book" will be recognized as a marked advance in the literature of the subject which it considers. Nursing as a practical art grounded in scientific principles, and an important adjunct of the medical profession with its own schools, belongs among the useful hygienic improvements of the last few years. In its early stages, as was most natural, its class-books were crude and imperfect. There has been a very valuable literature pertaining to nursing, but it has chiefly consisted of "Notes," "Essays," "Fragments," and imperfectly compiled rules and suggestions which, however useful and indispensable, have fallen much short of the requirements of systematic study. There was room here, and urgent need for something better, which the author of this book, moved by her own unsatisfactory experiences as a student, has now effectively supplied. She has given us a volume conformed to the established habits of school-study, complete in its treatment of the several subjects with which the intelligent nurse should be familiar, well illustrated, with copious questions for class-exercise and review, and a full glossary of technical terms. Her contribution is certain to prove helpful in the work of education, and she may be congratulated on having done an excellent service in helping on the progress of her profession.

But the usefulness of the "Text-Book" will not be confined to the limits of the Training-Schools for Nurses. It is of far wider application, and should find place in every family. It is full of information, to which every woman who cares for the vital interests of her household should have access. Clearly, popularly, and attractively written, it can be understood by everybody, and women who never expect to go into the nursing business professionally will be much better prepared to meet the emergencies and responsibilities of domestic life—to deal with the sickness that is at some time inevitable—by reading and familiarizing themselves with much of the instructive contents of this work. A good deal in it is, of course, only for the regular nurse; but there is enough of general application, and even of almost every-day utility in household experience, to justify us in commending it cordially to all thoughtful mothers as one of the books that they should have always at hand.

THE STUDY OF POLITICAL ECONOMY: Hints to Students and Teachers. By J. LAURENCE LAUGHLIN, Ph. D., Professor of Political Economy in Harvard University. New York: D. Appleton & Co. Pp. 153. Price, $1.

PROFESSOR LAUGHLIN in this useful little book aims to present the claims of the sub-

ject upon those engaged in education, to show its disciplinary value, and to give important hints and suggestions as to how it may be most successfully pursued. Notwithstanding all the discussion there has been as to whether political economy is a true science or not, or as to the validity or relative superiority of its different methods, the subject is one which engages wide attention and is of foremost interest and importance. It deals with what is going on and must continue to go on in society under good or bad guidance, and where knowledge is certainly better than ignorance. The author has therefore done an excellent and necessary thing in showing students how they can best proceed in informing themselves on political economy, whether they wish merely to get an acquaintance with its rudiments or to master the subject. He gives the list of a teacher's library selected from English, French, and German authors, which can not fail to prove useful.

PHILOSOPHIC SERIES. By JAMES MCCOSH, D. D., LL. D. Nos. I to VIII, 50 to 70 page pamphlets. New York: Charles Scribner's Sons. Price, 50 cents each.

IT was a very happy conception of the able President of Princeton College and distinguished metaphysician, Dr. McCosh, to take up the most urgent and interesting philosophical questions of the time, and treat them in the popular way here adopted. There can be no doubt that philosophical speculation has a good deal about it that is progressive. As long as thinkers shut themselves up to such pure metaphysical elaborations as they can carry on in the restricted sphere of consciousness, the resulting movement will be round and round rather than an advance or ascent; but, when they seize the conception of philosophy in its broader aspects, and connect it with those large questions of Nature and life which have come into such prominence in recent times, a distinctively forward movement is the result. When such great new principles as the conservation of energy or the law of development are projected into the philosophical field, and their import is recognized by the speculative mind, onward movements which can be regarded as nothing less than a new departure are the inevitable consequence. Dr. McCosh is not the narrow type of man to blink or to belittle the significance of these mighty ideas which have been forced upon philosophy by modern science; he not only meets them, but he welcomes them as priceless contributions to knowledge, to be perhaps yet further interpreted and qualified, but, neither to be feared nor resisted. Aside from his mastery of general philosophical subjects, and his familiarity as a scholar with the history of speculation, his knowledge of science and his sympathy with it, and his thorough acquaintance with the critical issues which have become prominent in the thought of this generation, especially qualify Dr. McCosh to give instructiveness to such a series of essays as he has here undertaken.

No formal review of the work is here practicable; we can only indicate his successive topics. No. I considers "Criteria of Diverse Kinds of Truth, as opposed to Agnosticism." No. II, "Energy: Efficient and Final Cause." No. III, "Development: What it can do, and what it can not do." No. IV, "Certitude, Providence, and Prayer." No. V, "Locke's Theory of Knowledge, with a Notice of Berkeley." No. VI, "Agnosticism of Hume and Huxley, with a Notice of the Scotch School." No. VII, "A Criticism of the Critical Philosophy." No. VIII, "Herbert Spencer's Philosophy as culminated in his Ethics."

President McCosh is a Doctor of Divinity, and the course of topics in this discussion shows that it has been prepared with reference to its theological bearings. But the controversial element is moderate in tone, and is subordinate to the expository element. We commend the pamphlets for the clearness and instructiveness of their teachings on philosophical questions, without being at all committed to the author's conclusions respecting theology or morality. On these points he seems often to betray the weakness of the thorough-going partisan of a dogmatic system.

SPECIAL REPORT OF THE STATE INSPECTOR (MINNESOTA) OF OILS ON THE ILLUMINATING QUALITY OF OILS. By HENRY A. CASTLE. St. Paul. Pp. 24.

THE inspector relates that frequent and numerous complaints came to him during 1884 of the inferior illuminating powers and

other poor qualities of the kerosene-oils used in the State. He sought explanations from the wholesale dealers and agents of the oil companies, but could not get satisfactory ones; and it was not till he had begun to take measures for enforcing the laws against selling adulterated or inferior goods, that proper notice was taken of his remonstrances. Then the agent of the Standard Oil Company made a confession presenting almost the identical statement made by Professor Peckham, in the June number of the "Monthly," of the deteriorated character of the burning-oils in common use and its causes; and we refer our readers to Professor Peckham's article for more specific information on the subject.

THE AZOIC SYSTEM AND ITS PROPOSED SUBDIVISIONS. By J. D. WHITNEY and M. E. WADSWORTH. Cambridge, Mass.: Harvard Museum of Comparative Zoölogy. Pp. 250.

THE authors review the whole literature of their subject, beginning with the reports of the Canadian and other British-American surveys, and following with those of the New England and Atlantic seaboard States, Texas, Arkansas, Missouri, Michigan, and Wisconsin, and the Government surveys in the West, for the purpose of ascertaining the condition of the theory of the Azoic system. The reports examined concern the results of forty years of work. In a second part they give a "*résumé* and general discussion" of their review, the result of which is to lead them to the conclusion that "the geology of a large portion of this country, and especially that of Canada and New England, is in an almost hopeless state of confusion"; and "that our chances of having at some future time a clear understanding of the geological structure of Northeastern North America would be decidedly improved if all that has been written about it were struck out of existence." This condition of things is largely ascribed to the erroneous observations and theories of the Canada survey, "which to a large extent have been adopted and blindly followed on this side of the Dominion boundary." Finally, "the present director of the Canada survey appears to be sincerely endeavoring to base his work on better methods than those current under Logan's administration. All who are interested in the solution of the difficult problems of Appalachian geology will sympathize with him in these efforts; for . . . that which is done in Canada will, *if well done*, be of great assistance to those working on the south side of the Dominion line."

THE GRIMKÉ SISTERS: SARAH AND ANGELINA GRIMKÉ. The First American Women Advocates of Abolition and Women's Rights. By CATHARINE H. BIRNEY. Boston: Lee & Shepard. Pp. 319. Price, $1.25.

THE interesting characters to which this volume is devoted are now historic. The Grimké sisters have passed away, and the record of their remarkable careers will have a double interest: first, for those who knew, admired, and loved them; and, second, for all others who take interest in those great public events leading to the overthrow of slavery in this country, with which these ladies were early and long and intimately associated. Angelina and Sarah Grimké were gifted women of superior intellectual stamp and high moral aspirations, who gave their lives to the active promotion of various reforms with fearlessness, independence, and devoted purpose, to make the world better as far as lay in their power. They were both of a deeply religious cast of mind, and entered early into church relations in their native city of Charleston, South Carolina. But the perfunctory round of ordinary religious exercises could not satisfy them. Religion was in their blood, and the type of it was that of tragic earnestness. They were descended on the father's side from the Huguenots, and on that of the mother from the old Puritans, with whom religion was a stern reality. Possessing hearts sympathetic with the sufferings of their fellow-creatures, and heads endowed to discriminate the means of relief, they could not remain impassive in their Charleston environment. The subject of slavery, with which they had been, of course, long and painfully familiar, took hold of them as a matter of religious duty. They left the Episcopal Church because it seemed given over to worldliness, and was unmindful of its Christian obligations to the slave. Angelina joined the Presbyterians, in the hope of finding them more alive to their practical religious duties,

and Sarah for the same reason, though still earlier, joined the Society of Friends. Both left Charleston and went to Philadelphia, where Angelina also became a Quaker. But after years of trial they withdrew also from the Friends' organization, for the same reason that it did not enter heartily into the rising movement for emancipation. Breaking away from all these restraints, they came out openly as Abolitionists, and devoted themselves with great zeal and efficiency to the propagation of antislavery views. They wrote much and forcibly, and at length took the field as speakers in Massachusetts with remarkable effect. They were both eminently qualified for this sphere of labor, but Angelina, the younger, had extraordinary accomplishments as an orator, and her lectures were attended by crowds of admiring listeners, although the appearance of women in the public lecture-field was at that time a novelty, and strenuously resisted by all conservative people.

Slavery is now gone, and a new generation has come upon the stage which knows little of the intensity of the struggle which led to its extinction, and the furious and maddened resistance encountered by its assailants; but in the records of that experience the names of the Grimké sisters will ever have an honorable and permanent place. Of their various efforts in other directions of social reform, their personalities, and their interesting private lives, we can not here speak, but must refer the reader to the memorial volume, which has been executed with fidelity and discriminating fairness by a loving friend. It will be sincerely welcomed by all who knew them, and will be found full of instructive interest by all who have an appreciation of strong, elevated, and heroic character.

STATE AGRICULTURAL EXPERIMENT STATION, AMHERST, MASS. Second Annual Report. 1884. C. A. GOESSMANN, Director. Pp. 166.

THE varied contents of this report, and the fullness with which the experiments are described, testify to a year of busy work. Among the subjects of the experiments were commercial fertilizers, the specific action of different forms of potassa, the effect of fertilizers on fruit-trees, various leguminous forage-plants, injurious insects, the vitality of seeds, ensilage, foods, analyses of milk, testing of drinking-waters, feeding-experiments with milch-cows and pigs, etc.

PLACER MINES AND MINING-DITCHES. By ALBERT WILLIAMS, Jr. Pp. 64.

THIS monograph was prepared to form a part of the census report on the statistics and technology of the precious metals. Placer mines, according to the author's statement, have the advantages of being usually more accessible and nearer to thickly settled and agricultural districts than the quartz mining districts, and of not requiring so large an amount of material for their working as quartz mines. The secondary nature of the gravel deposits in which they occur implies an average lower altitude than that of the quartz veins, from which they are derived by erosion. It is a fact that they occur at all altitudes up to 10,000 feet, the elevation of the placer in Alma township, Park County, Colorado. The average height of those mentioned in this report is more than 3,400 feet above the sea-level, while the average height of those in California, beach-sands excepted, is 2,600 feet. The total nominal capital of thirty-six placer mines is $35,115,000, or an average of $975,417 each, while the average par value of their shares is about $14.68. The placer mines being largely worked by the hydraulic method, the question of water-supply is an important one with them, and extensive ditching-works have been executed to secure water. Mr. Williams has reports of 10,783 miles of ditch-lines, which have a maximum capacity of 7,560,000 gallons per twenty-four hours, which cost for plant, excluding cost of water-rights, $27,056,942, and are maintained at an annual expense of $837,280.

THE INFLUENCE OF THE PROPRIETORS IN FOUNDING THE STATE OF NEW JERSEY. By AUSTIN SCOTT. Baltimore: N. Murray. Pp. 26.

THIS is a study in the Johns Hopkins University Historical Series, by the Professor of History in Rutgers College, of the course of the development of the fundamental institutions of New Jersey from the *régime* laid down by the original proprietors.

NATURAL CO-ORDINATION AS EVINCED IN ORGANIC EVOLUTION. A Paper read by WILLIAM FRASER, M. D., before the British Association for the Advancement of Science at its Montreal Meeting, September 1, 1884. New Glasgow, Nova Scotia: George W. Chisholm.

IF it would be too much to say that Dr. Fraser, in this philosophical essay, has solved the supreme question of the nature of that governing power by which an evolving universe works out its highest results, it is not too much to say that he has made a reasonable and a valuable contribution toward such a solution. We can not here give his closely knit argument, but must be content with indicating the ground taken. He begins by remarking that "matter and force constitute the present scientific basis of the natural universe; but as unco-ordinated entities they might remain forever inoperative." This idea is so illustrated and enforced as to bring out the necessity of affirming a presiding directive and co-ordinating principle as a part of the order and constitution of Nature, and without which development is a wholly inexplicable process. Dr. Fraser's statement of the case of evolution as against special creation, and in the variety of its proofs, is thus admirably summarized:

The persistency with which succeeding links in the same organic chain approximate to a common mean type, along with certain prevailing sentiments and supposed teleological implications, has influenced many naturalists to accept the doctrine of special creation as a satisfactory explanation of the origin of species; to believe that each distinct kind was immediately introduced with its present congeries of characters complete and immutable, adapting it to a prepared station, and having the principle of heredity so strongly implanted as to prevent its members from ever deviating beyond the limits of acknowledged specific divergence.

From studying the question under other aspects, some observers have been induced to adopt an opposite view, and to conclude that all actual diversities were potentially inherent in matter and energy at their original creation and disposition, and have been spontaneously evolved through natural causes, without any supernatural interference.

Having learned the apparent potency of natural means and methods in producing all past physical changes, they feel constrained to recognize these as fully adequate to sustain the whole sum of terrestrial activity, including the processes and products of organization; deeming it more credible that the total system of development, in common with all other material objects and events, should form an essential and interdependent part of the more comprehensive scheme of Nature, than that each distinct species should have its source in a miraculous act of creation.

Observing, under varying artificial conditions, the occasional production of several acknowledged VARIETIES from a common stock, and the perpetuation of such only as can provisionally conform with the conventional requirements of their situations, they infer that SPECIES originated and have been transmitted in a similar way, but carried further and established more firmly, either in consequence of more powerful impulses or of greater time and opportunities afforded.

They also find that all the species of the same genus, inhabiting adjacent and intercommunicable areas, have closer structural relationships than those of more remote and mutually isolated regions, and that any differences which exist in the former case are superficial, as if the later divergences had rarely and but slightly affected their fundamental characters.

Fossils also are generally found more nearly allied to the fauna and flora of their own particular territory than to those of distant provinces; and in the later deposits more so than in those of earlier strata.

Paleontological arrangements likewise indicate a gradual advance from generalized to specialized forms, from the simple earliest structures up to the relatively complex types of the present age.

Embryological development also shows a general progress from the indefinite to the definite; all organic germs at their origin being scarcely distinguishable from one another; the earlier fœtal stages of many different classes of animals being almost parallel; and in the higher orders, their later phases being attended by a gradually decreasing number of companions, till man, the highest vertebrate, at length alone acquires distinctively human features. Besides, underneath certain diversities of surface, which constitute specific morphological distinctions, there is often a fundamental unity; the arms of a man, the flippers of a whale, the fore-legs of a horse, and the wings of a bird being constructed on essentially the same general pattern, though differing greatly in special details, as if a common ancestral organ had become differently modified in each particular case, in subordination to, and in conformity with, correlated conditions.

Rudimentary structures often show the potency of heredity in preserving parts long after they have ceased to be serviceable; and occasionally they represent the transition to some more complete and permanent advantageous acquirement.

In general, the more invariable and radical organic structures are diffused among much larger aggregates than are less permanent and less important ones.

The spinal column, which pertains to the whole vertebrate sub-kingdom, holds tolerably constant specific characteristics within the same class, whereas the dermal appendages not only manifest much diversity in different species, but often display considerable difference even in members of the same variety.

All these complex and diversified relations are considered indicative of community of origin, with subsequent adaptive modifications.

Certainly geographical distribution, geological

succession, morphology, embryology, classification, and many other peculiarities of organization, such as its fundamental unity of composition, but more especially the fact, so far as has yet been proved, of the derivation of all observed individuals from more or less similar parent stocks, constitute a remarkable collection of accumulating and converging lines of evidence in favor of the doctrine of specific organic descent.

These proofs, however, are merely circumstantial; the relation of this problem to human experience being such as to render it incapable of demonstration; still, the gravest objection to the theory of organic transmutation is the difficulty of understanding how matters could have been so constituted and arranged that from simple and indefinite beginnings such wonderfully complex and determinate results could have been obtained. NATURAL SELECTION does not account for the origin of specific characters, but merely explains how, out of numerous so-called spontaneous variations, such only can be preserved as are in sufficient harmony with their environments.

And, while changing incidence of conditions is undoubtedly instrumental in determining organic sequences, it is important to ascertain what is the nature of the factors engaged, and how they cooperate in the evolution and establishment of distinct specific characters.

The main conception of Dr. Fraser's thesis may be gathered from the following passages:

The mere association of developmental impulses and envelopmental facilities and restraints could never of itself issue in any definite progressive result, unless subjected to the determination of some controlling principle of order. Hence the regularity, definiteness, and consistency observable in organic reactions and relations testify to the additional existence and jurisdiction of a supplementary principle of co-ordinative supervision.

As man, by factitiously arranging the means at his disposal in accordance with his needs and tastes, institutes systems of artificial co-ordination, so the spontaneous adjustment of organic activities, in subjection to, and in conformity with, prevailing correlated tendencies and requirements, constitutes a principle of NATURAL CO-ORDINATION. In the elaboration and establishment of specific organic results, this *principle* fulfills the two distinct though complemental offices of a *directive* and a *selective* function; the former determining each temporary step in the process, the latter deciding which out of many courses will be permanently or successively adopted.

In a dependent evolving system, with abundant accommodation, provisions, and protection, it might remain a matter of indifference what number and kind of forms were produced, as all would alike be preserved, each phase being simply a resultant of the interaction between inward efforts and outward restraints, without the intervention of any subsequent eliminating process. Here the principle of co-ordination could only have directive scope; but, in a circumscribed area with limited supplies and liability to invasion, as soon as the rate of production exceeds the means of support, co-ordination will assume a selective *rôle*, submitting the various competitors for the different accessible situations to prescribed tests, accepting only such as conform with the required standards, and rigorously rejecting all relatively unsuitable or incompetent ones.

Organization seems to have been planned and conducted according to some such method and design; *its potentialities, when properly supplemented, constituting an incalculable fund of transmutable and genetic energies, affording the principle of co-ordination enormous resources whereon to operate*, so as to render possible the realization of results practically inconceivable.

POPULATION BY AGES, UNITED STATES, NEW YORK, PHILADELPHIA, AND BALTIMORE. By W. S. LANDSBERG. Baltimore, Md. Pp. 30. Price, 10 cents.

THE author believes that the distribution of a population according to the ages of the individuals is not fortuitous, but is the result of the influences which all the circumstances of a people's life exert upon its existence, naturally conditioned by births and deaths. In the light of this view he discusses the lessons to be drawn from the vital statistics of the United States and the three cities named.

THE MINTING OF GOLD AND SILVER. By ALBERT WILLIAMS, Jr. Pp. 24.

THIS paper was prepared to form a part of the census report. Without attempting an exhaustive treatise on modern practice in minting, Mr. Williams reports upon the processes employed in the mints at Carson, Nevada, and San Francisco, California.

THE MODIFICATION OF PLANTS BY CLIMATE. By A. A. CROZIER. Ann Arbor, Mich. Pp. 35. Price, 25 cents.

IN this pamphlet the author discusses a subject concerning which our present knowledge is "scattered and unsatisfactory," and on which he desires to elicit more information. From the facts he has been able to adduce he concludes that enough has been observed to make it evident that variation is not accidental or at random, but is, at least in part, in definite directions and due to definite causes. "It seems to be established that as plants move from the locality of their largest development toward their northern limit of growth they become dwarfed in habit, are rendered more fruitful, and all parts become more highly colored. Their

comparative leaf-surface is often increased, their form modified, and their composition changed. Their period of growth is also shortened, and they are enabled to develop at a lower temperature. These variations, if useful, may be accumulated by selection and inheritance."

SECOND ANNUAL REPORT OF THE BUREAU OF STATISTICS OF LABOR OF THE STATE OF NEW YORK, FOR THE YEAR 1884. CHARLES F. PECK, Commissioner. Albany: Weed, Parsons & Co. Pp. 521.

THE attention of the Bureau during the year included in the report was directed chiefly to the investigation of the prevalence of child-labor in the manufactories of the State, in which, in spite of adverse circumstances growing out of the defects of the law under which the inquiries were conducted, and of the difficulty of getting employers to give information, a great many valuable statistics and much important testimony have been collected. The facts relate to the employment of children; its influence upon their physical development; the opportunity afforded in connection therewith for moral and educational training; and its relation to the social, commercial, and industrial prosperity of the State. A considerable portion of the report is devoted to the subject of compulsory education, the importance of securing the enforcement of the law prescribing it, and the means of accomplishing it. An article on "Hygiene of Occupation," by Dr. Roger S. Tracy, of New York, is also included in the report. In the appendix are given a report on Pullman, Illinois; the memoranda of a committee visit to the houses of cotton-mill operatives in Fall River, Massachusetts; the labor laws of New York; and extracts from the labor legislation of other States and of England.

A B C BOOK. By FRANCIS A. MARCH. Boston: Ginn & Co. 20 cents.

PHONETIC FIRST READER. By T. R. VICKROY. Cincinnati: Van Antwerp, Bragg & Co. 25 cents.

ANGLO-AMERICAN PRIMER. By ELIZA B. BURNZ. New York: Burnz & Co. 15 cents.

PRONOUNCING ORTHOGRAPHY. By EDWIN LEIGH.

AMERICAN PHONETIC PRIMER. By ELIAS LONGLEY. New York: E. N. Miner. 25 cents.

FIRST BOOK IN PHONETIC READING. SECOND BOOK. THIRD BOOK. FOURTH BOOK. FIFTH, OR TRANSITION BOOK. By ISAAC PITMAN. New York. Fowler & Wells Co. The set, 26 cents.

AN article in the September number of the "Monthly" having caused some inquiry for phonetic primers, a number of these books are here noticed. They have the common object of making easy the first part of the process of learning to read by removing the difficulties of silent letters, and letters with several powers, to a later stage. The authors make the claim, and support it by abundant evidence, that children learn to read books in phonetic spelling, and then master the ordinary print, in less time than is commonly spent on the ordinary print alone. It is claimed, further, that in learning to read by the phonetic method the child's reasoning powers are stimulated, while if taught in the old way it forms at the outset a habit of dependence on the teacher which impedes all future progress. Some of these books recognize thirty-six, the others forty or forty-one, simple sounds in the English language, besides four or five diphthongs; and, as the common alphabet contains only twenty-three effective letters, it is variously extended by new letters and digraphs. Longley uses seventeen new letters; Pitman thirteen, with digraphs for the diphthongs; Vickroy eleven, with eight digraphs; while Mrs. Burnz uses but three, depending largely on familiar digraphs. Dr. Vickroy's reader has on the title-page a note, signed by Professor March as president of the Spelling Reform Association, in which he cordially recommends the book. As Mr. Pitman's books are published in England, the pronunciation which they represent differs slightly from American usage. Thus the vowel sound in *lair* is not distinguished from that in *layer*; *been* is represented as rhyming with *seen*, etc. Pitman and Longley use the continental vowel-scale, Mrs. Burnz the English, while March and Vickroy skillfully avoid conflict with either. Mrs. Burnz retains duplicate ways of representing several sounds, and a few other irregularities of the old spelling, claiming as compensation that her spelling departs less from the common mode than any other, and hence that a person whose education went no further than the phonetic stage could spell a

letter so that it would not fail to be understood by any one who went through the spelling-book in the old-fashioned way. Dr. Leigh's "Pronouncing Orthography" retains the common form of every word, but silent letters are printed in hair-line type, and the significant letters are so modified that it is always plain what sound they stand for. Ten or a dozen primers and readers by various authors have been published in Leigh's pronouncing editions. Professor March uses Dr. Leigh's types for nine single letters and five digraphs in his "A B C Book." Words containing silent letters are postponed to a later stage. A part of his general method is to have the pupils begin to write with the first lesson, but this may be omitted if the teacher prefers. The transition from any of the primers mentioned above to common print is said to be easy, but, if it seems desirable to keep the pupils longer on the phonetic print, second readers or other supplementary matter can be had in most of the systems for this purpose.

ZOÖLOGIC WHIST AND ZOÖNOMIA. By HYLAND C. KIRK. New York: McLoughlin Brothers. 104 Cards. Price, $1.

AN attempt is made in these cards to combine amusement, as it is sought in playing whist, with instruction in the principles of a science. The cards, on which the classification of animals is graphically represented, are arranged in two packs of fifty-two cards each, one including the vertebrates, the other the invertebrates. Each pack is divided into four suits, representing the classes and thirteen orders. The rank of the orders being fixed according to numbers printed on the cards, the game is played as whist is played. The game of zoönomia is played with all the cards, or a smaller number, and is in effect an exercise on the qualities of the orders of animals represented upon them.

THE TEHUANTEPEC SHIP-RAILWAY. By E. L. CORTHELL, Civil Engineer. Pp. 32, with Plates.

THIS is the substance of an address that was delivered before the Franklin Institute in December last, in which the plan of the railway as projected by Captain Eads is explained, and its feasibility and the prospective advantages to be derived from carrying it out are considered.

PAPERS OF THE AMERICAN HISTORICAL ASSOCIATION. Volume I, No. 1: Report of Organization and Proceedings. Pp. 44. No. 2: Studies in General History and the History of Civilization. By ANDREW D. WHITE. Pp. 28. New York: G. P. Putnam's Sons. Price, 50 cents each.

THE American Historical Association was organized at Saratoga in September, 1884, with Andrew D. White as president, and Herbert B. Adams, of Cornell University, as secretary, for the promotion of historical studies, and has registered already, for a society so new, a large list of members. It will publish original contributions to history in the form of serial monographs, each complete in itself, bearing its own title, pagination, and price; but the monographs will be also numbered in the order of their publication, and paged continuously with the series, for the annual volume. They are sent to members of the Association who pay their annual fee of three dollars, and to other persons for four dollars a volume. The address of President White is a forcible presentation of the value of historical studies, and suggests ways in which they may be made most efficient.

EFFICIENCY AND DURATION OF INCANDESCENT ELECTRIC LAMPS. Report of Committee, Franklin Institute of Pennsylvania. Pp. 127.

A SPECIAL committee was appointed by the Board of Managers of the Franklin Institute in November, 1884, to conduct examinations and make tests of the efficiency and life-duration of incandescent lamps. It having prepared a code of conditions to which all competitors were expected to conform, Weston, Edison, Woodhouse and Rawson, Stanley-Thompson, and White lamps were entered, for competition or for comparative examination. The history of the testing, its incidents, and its results, are recorded in detail in the report.

TRANSACTIONS OF THE SIXTEENTH AND SEVENTEENTH ANNUAL MEETINGS OF THE KANSAS ACADEMY OF SCIENCE (1883, 1884). E. A. POPENOE, Manhattan, Secretary. Pp. 145.

THE Kansas Academy is evidently a working body. This volume of the "Transactions" contains notices or abstracts of forty-nine papers and reports read at the two meetings, all of them of much local and

some of considerable general interest. We specially notice the two presidential addresses. The first, by retiring President Dr. A. H. Thompson, is concerning the "Origin and History of the Academy," and gives a rapid review of the growth of scientific work in Kansas, and of the transactions of the fifteen previous annual meetings of the society. The other address, by Dr. R. J. Brown, is a discussion of the question, "Is a Geological Survey of the State a Necessity?" and presents summaries of the benefits that have accrued from their surveys in other States in which such works have been prosecuted.

THE HOOSIER NATURALIST. Vol. I, No. 1, August, 1885. A. C. JONES and R. B. TROUSLOT, Editors and Publishers, Valparaiso, Ind. (Monthly.) Pp. 8. Price, 50 cents a year.

THE editors claim to have in Valparaiso a rare combination of facilities to encourage the publication of a scientific journal, including a large normal school, with classes in zoölogy, geology, and botany; the Museum of the American Institute, of which one of them is custodian; and surroundings of excellent collecting-grounds. Such enterprises as this are evidence of a living love for science, and help to stimulate and extend it.

AIMS AND METHODS OF THE TEACHING OF PHYSICS. By Professor CHARLES K. WEAD. Washington: Government Printing-Office. Pp. 158.

THE author of this paper was commissioned by the Commissioner of Education to draw up a set of inquiries respecting the teaching of physics, send them to teachers, and collate and discuss the answers which should be received. The questions related to various points respecting the expediency of the teaching, the prominence and extent that should be given to it, and the method in which it should be done. Answers were received from seventy-two teachers in normal and secondary schools and colleges and universities, and other persons experienced in educational work, and are here given and reviewed. To these is added information from other countries. This is followed by an attempt to discover that consistent scheme of physics study which is favored by the majority of the contributors.

## PUBLICATIONS RECEIVED.

Wintering Bees. By A. J. Cook. Agricultural College of Michigan. Pp. 6.

Impounding the Nile Floods. London: The Bedford Press. Pp. 6, with Map.

Pittsburg and Western Pennsylvania. Issued by the Pittsburg Chamber of Commerce. Pp. 188. With Map.

Something about Natural Gas. By George H. Thurston. Pittsburg. Pp. 32.

Franklin Institute, Philadelphia. Lecture Programme. 1885-'86.

Insanity of the Past, pp. 8; Report on Cerebro-Spinal Pathology, pp. 18; Forty Years of Cerebro-Spinal Pathology, pp. 16. All by Dr. Daniel Clark. Toronto, Ont.

American Economic Association. Constitution, etc. Richard T. Ely, Secretary. Baltimore, Md. Pp. 16.

The Climatic Treatment of Phthisis. By Harold Williams, M. D. Pp. 19.

Diana. New York: Burnz & Co. Pp. 56.

Sensory Aphasia. By Morton Prince, M. D. Boston. Pp. 14.

Studies from the Biological Laboratory of Johns Hopkins University. Baltimore: N. Murray. Pp. 24. Price, 30 cents a number. $3 a volume.

Moral and Material Progress contrasted. By Lester F. Ward. Washington: Judd & Detweiler. Pp. 16.

Syllabus of the Instruction in Biology. By Delos Fall. Albion, Mich. Pp. 24.

United States Government Publications. Monthly Catalogues, Nos. 7 and 8. Washington: J. H. Hickox. Pp. 20 each.

Juarez and Cesar Cantú. Refutation of Charges preferred by the Italian Historian. Official edition. Mexico: Government Printing-Office. Pp. 55.

Remarkables protubérances solaires (Remarkable Solar Protuberances), pp. 3; La planète Saturne en 1885 (The Planet Saturn in 1885), pp. 4; Observation d'une essaim de corpuscules noirs passant devant le soleil (Observation of a Swarm of Black Corpuscles passing in Front of the Sun), pp. 3; Murs énigmatiques observés à la surface de la lune (Enigmatical Walls observed on the Surface of the Moon), pp. 4; Sur la structure intime de l'enveloppe solaire (On the Intimate Structure of the Solar Envelope), pp. 29. With Plates. All by E. L. Trouvelot. Paris.

Distribution of the Reserve Material of Plants in Relation to Disease. By D. P. Penhallow. Pp. 10.

The Preparatory Schools and the Modern Language Equivalent for the Greek. By Charles E. Fay, Tufts College. Pp. 16.

Addresses at the Complimentary Dinner to Benjamin Apthorp Gould. Lynn, Mass.: Thomas P. Nichols. Pp. 40.

The Lick Observatory, Mount Hamilton, California. By David P. Todd. Pp. 24.

Extensions of Certain Theorems of Clifford and of Cayley in the Geometry of *N* Dimensions. By E. H. Moore, Jr. Pp. 8.

Main Drainage and Water-Supply of Chicago. Report of Committee of Citizens' Association. J. C. Ambler, Secretary. Pp. 32.

The Relations between the Theromorphous Reptiles and the Monotreme Mammalia, pp. 12; and Various Geological and Paleontological Notes. By E. D. Cope. Philadelphia.

Aim and Method of the Rōmaji Kai, or Roman Alphabet Association of Japan. Tokio: Imperial Printing-Office. Pp. 28.

Pounding and Polishing Rice in England and Germany, pp. 10; The Licorice-Plant, pp. 20. (United States Consular Reports.) Washington: Government Printing-Office.

Report on Sanitary Improvement Bonds of

Jacksonville, Fla. R. N. Ellis, Superintendent. Pp. 45.

A Year's Scientific Progress in Nervous and Mental Diseases. By L. A. Merriam, M. D. Omaha, Neb. Pp. 7.

Value and Management of Government Timber-Lands, etc. Pp. 47. Agricultural Colleges and Experiment Stations; Convention Proceedings. Pp. 196. (Special Reports, Department of Agriculture.) Washington: Government Printing-Office.

Notes on Fruits, Vegetables, and Ornamental Trees and Shrubs. By L. H Bailey, Jr., Agricultural College of Michigan. Pp. 11.

Study out of School-Hours. By L. M. Parish, Independence, Iowa. Pp. 6.

Lighting and Seating School-Houses. By L. F. Andrews, Des Moines, Iowa. Pp. 45.

Sanitary Science and Public Hygiene, pp. 9. Over-pressure in Schools, pp. 11. By W. S. Robertson, M. D., Muscatine, Iowa.

Evolution and Religion. Eight Sermons. By Henry Ward Beecher. New York: Fords, Howard & Hulbert. Pp. 145.

On the Temperature of the Surface of the Moon. By S. P. Langley, F. W. Very, and J. E. Keeler. Pp. 32, with Plate.

Architectural Studies. Store-Fronts and Interior Details. Edited by F. A. Wright. New York: William T. Comstock. Twelve Plates. $1.

Milk Analysis and Infant Feeding. By Arthur V. Meigs, M. D. Philadelphia: P. Blakiston, Son & Co. Pp. 102. $1.

A Guide to Sanitary House-Inspection. By William Paul Gerhard, C. E. New York: John Wiley & Sons. Pp. 145. $1.25.

Protectionism. By William Graham Sumner. New York: Henry Holt & Co. Pp. 172.

Elizabeth, or the Exiles of Siberia. From the French of Mme. Sophie Cottin. New York: William S. Gottsberger. Pp. 149.

Twenty Years with the Insane. By Daniel Putnam. Detroit: John MacFarlane. Pp. 175. 75 cents.

Lectures on the Principles of House Drainage. By J. Pickering Putnam. Boston: Ticknor & Co. Pp. 125.

Louis Agassiz: his Life and Correspondence. Edited by Elizabeth Cary Agassiz. Boston: Houghton, Mifflin & Co. 2 vols., pp. 792. $4.

The Last Meeting. By Brander Matthews. New York: Charles Scribner's Sons. Pp. 268. $1.

Mind-Culture on a Material Basis. By Sarah Elizabeth Titcomb. Boston: Cupples, Upham & Co. Pp. 288.

Rudder Grange. By Frank R. Stockton. New York: Charles Scribner's Sons. Pp. 322.

The German Verb-Drill. By Adolphe Dreyspring. New York: D. Appleton & Co. Pp. 275. $1.50.

Marvels of Animal Life. By Charles Frederick Holder. New York: Charles Scribner's Sons. Pp. 240. $2.

The Commonwealth of Georgia. Part I. The Country. By J. F. Henderson, Commissioner of Agriculture, Atlanta. Pp. 379. $1.

Miscellanies. By C. C. Merriam. Rochester, N. Y.: Judson J. Withall. Pp. 342, with Photographic Plates.

The Blood Covenant: A Primitive Rite and its Bearings on Scripture. By H. Clay Trumbull, D. D. New York: Charles Scribner's Sons. Pp. 358. $2.

Methods of Research in Microscopical Anatomy and Embryology. By Charles Otis Whitman. Boston: S. E. Cassino & Co. Pp. 235. $3.

Report on Forestry. Prepared by Nathaniel H. Egleston. Vol. IV. 1884. Washington: Government Printing-Office. Pp. 421.

The Boys' and Girls' Pliny. By John S. White. New York and London: G. P. Putnam's Sons. Pp. 326. $3.

Fourth Annual Report of the United States Geological Survey. 1882, 1883. By J. W. Powell, Director. Washington: Government Printing-Office. Pp. 473.

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## POPULAR MISCELLANY.

**The American Forestry Congress.**—The American Forestry Congress held an interesting session in Boston in September. About a hundred members were present, who, by their own enthusiasm and by the reports they were able to make of the growth of interest in the subject, testified to the healthy progress which the cause of the protection and renewal of the woods is making in this country. Arbor-day is now observed as a festival in fifteen States, in a manner which well shows that the public are gradually coming into an appreciation of the sentiment which it typifies. Forest commissioners or commissions have been appointed by a number of States. Professor B. G. Northrup described the experiment of Mr. H. G. Russell, of East Greenwich, Rhode Island, in cultivating coniferous and deciduous trees upon a tract of two hundred acres along the shores of Narragansett Bay, sixty acres of which was a barren "sand-blow," where every one said no trees could be made to grow. His method was to protect the trees and fix the sand by brush until the trees (which were set out) could take care of themselves. A resident stated that land on Cape Cod, which was a drug at twenty-five or fifty cents an acre twenty-five years ago, was now, in consequence of the growth of trees upon it, worth twenty dollars an acre, and desirable for residences. Mr. Fernow, corresponding secretary, read a paper on "Lumber-Waste as a Fertilizer." It proposed a plan for the utilization of the brush, etc., left by the loggers, which is now nothing but material for starting forest-fires, by rending it up into fine shreds or shavings, and then using it as bedding for horses and cattle, after which it will become manure. Mr. Fernow presented facts which tend to show that such applications may be made with profit all around. The subject of forest-fires came under discussion, and statements were made respecting their preventability and showing that they do not cause so great a

proportion of the damage suffered by the forests as the lumbermen pretend that they do. Mr. Coleman, Commissioner of Agriculture, proposed the appointment of a committee to draft suitable forestry bills to be made laws by the General and State governments, and to labor with legislative committees to secure attention to them.

Among the other special topics considered in the papers were "Facts in regard to the Present State of American Forestry: State of Forest Legislation in the United States," N. H. Egleston; "What have the Different States done in regard to their Forests?" J. S. Hicks; "What are the Requisites of an Effective Forest-Fire Legislation?" S. W. Powell; "Lumbering Interests—their Dependence on Systematic Forestry," J. E. Hobbs; "Trees as Educators," Professor Edward North; "Profits of Forest-Culture," B. P. Poore; "Need of a National Forest Policy," Hon. Warner Miller; "Profits of Forest-Culture: State of Forest Legislation in the State of New York," Hon. H. R. Low.

**The History of a Game.**—Mr. J. W. Crombie read a paper before the British Association on what he styled "A Game with a History"—hop-scotch. As children in their play generally imitated something they had observed to be done by their elders, and a game once introduced was handed down from generation to generation, many innocent-looking children's games concealed strange records of ancient ages and pagan times. The game of hop-scotch was one of considerable antiquity, having been known in England for more than two centuries, and it was played all over Europe under different names. Signor Pitré's solar explanation of its origin appeared improbable, for not only was the evidence in its favor extremely weak, but it would require the original number of divisions in the figure to have been twelve instead of seven, the number indicated by a considerable body of evidence. It would seem more probable that the game at one time represented the progress of the soul from earth to heaven through various intermediate states, the name given to the last court being most frequently paradise or an equivalent, such as crown or glory, while the names of the other courts corresponded with the eschatological ideas prevalent in the early days of Christianity. Some such game existed before Christianity, and the author considered it had been derived from several ancient games. Possibly the strange myths of the Labyrinths might have had something to do with hop-scotch, and a variety of the game played in England, under the name of "round hop-scotch," was almost identical with a game described by Pliny as being played by the boys of his day. The author believed that the early Christians adopted the general idea of the ancient game, but they not only converted it into an allegory of heaven, with Christian beliefs and Christian names, they Christianized the figure also. They abandoned the heathen labyrinth and replaced it by the form of the basilica, the early Christian church, dividing it into seven parts, as they believed heaven to be divided, and placing paradise, the inner sanctum of heaven, in the position of the altar, the inner sanctum of the early church.

**The Indians of Mount Roraima.**—Mr. E. F. Im Thurm read some notes, in the Anthropological Section of the British Association, on the red-men about Mount Roraima, in British Guiana. He had found them still in the stone age, but not in the extremely primitive condition he had anticipated. There was no other place in British Guiana where the stone age still subsisted. These Indians live in small conical huts clustered into villages, and including a church, where they imitated, without understanding, the religious services they had seen at some far-off mission. They were generally ugly, some even repulsive, but hospitable and kind, and the reception the speaker's party had met with could not be surpassed in courtesy in the most civilized community. They made stone implements of a remarkable kind, such as adzes and axes, but stones were more usually fashioned, by a process of rubbing, into imitations of fish and articles of ornament. Their games were very interesting, some of them being imitations of animals, and others a kind of rhythmic swinging to a slow chant. The isolation of tribes, and even that of families, was remarkable. It had

been caused by the fact that most of the tribes seemed to have arrived from the West Indian Islands and the Orinoco, and to have followed one another to the interior, where each tribe took charge of a river, while almost impenetrable forests intervened between their settlements. In answer to a question, Mr. Im Thurm stated that, though stone implements were made, they were not used for any practical purpose, and that there was no trace of their having been used in any religious service. They were made as curiosities. He found no trace among the red-men of any acknowledgment of a higher power.

**Origin of the Whale.**—Professor Flower remarked, pertinently to a description by Dr. Struthers in the Biological Section of the British Association, of the Tay whale, that the whale carried its pedigree on its own body and in every part of its structure. It had been thought that mammals might have passed through an aquatic and marine stage before they came to the land. But observations of the anatomy of the whale showed that this could not have been the case. There could be no question whatever that the whale had been derived from a four-footed animal. It was a characteristic of a mammal to have a hairy covering. Whales were at one time thought to be an exception, but it was shown, in almost every one that had been examined, that at some period of its life it must have had a rudimentary covering, which was generally found in the neighborhood of the upper lip; that covering was functionless and often lost before birth. Another remarkable feature was the teeth. All these whales were furnished with a set of teeth, rudimentary but complete, and not characteristic of the fish, but of a more completely developed land mammal. These teeth entirely vanished at an early period, sometimes before birth; and they were entirely functionless.

**Insect Habits.**—Sir John Lubbock contributed to the recent meeting of the British Association a paper on some recent observations on the habits of ants, bees, and wasps. One of the most interesting points connected with the economy of ants was the manner in which they recognized their friends. Not only would the ants in any nest, however large, distinguish between their own companions and other ants belonging to the same species, but this had been shown to happen even after a separation of more than a year. Mr. McCook had thought the faculty was due to scent, but Sir John deduced reasons for believing it to be otherwise. As regarded the longevity of ants, he had two which he had kept ever since 1874. They were then full grown, and must therefore be twelve years old. They were both queens and continued to lay eggs, showing no signs of age, excepting, perhaps, that they were a little stiff in the joints. His experiments did not confirm the idea that these insects had any sense of direction, except perhaps in the same sense in which we might be said to have one. In continuation of previous experiments, Sir John had taken forty ants, fed them with honey, and put them down on a gravel path fifty yards from their nest. They wandered about in all directions, and it was obvious that they had no idea which was the right way home.

**Prolongation of Local Anæsthesia.**—The discovery has been made by Dr. J. Leonard Corning, of New York, that local anæsthesia produced by the subcutaneous injection of the hydrochlorate of cocaine may be prolonged by annulling the local circulation. The results of three experiments, described by Dr. Corning in the "New York Medical Journal," were to show, first, that simple arrest of the circulation in the part, shortly after injection of the anæsthetic, is sufficient to intensify and prolong the anæsthesia; second, that if the injection is made after exsanguination and compression, there is little diffusion of the anæsthetic, and consequently a commensurate diminution in the number of nerve-filaments exposed to the influence of the solution; and, third, that, if the injection is made a few moments before exsanguination and the application of the tourniquet, a sufficient amount of saturation of tissue is obtained to expose a large number of nerve-filaments to the influence of the anæsthetic; and yet, if the delay is not too long, there is no danger of diluting or dissipating the solu-

tion by the access of too much blood to such a degree as to weaken or nullify the anæsthetic influence. Since by this method the anæsthesia can be practically prolonged to an indefinite degree, repeated injections are no longer necessary for that purpose, and the object is attained by the use of comparatively small quantities of cocaine. Hence the danger of constitutional disturbances from overdosing is avoided. Dr. M. J. Roberts has applied the method suggested by Dr. Corning in operations occurring in his practice, with complete success, in cases of excavation of the condyles of the humerus; of an operation on the bones of the leg; and of excision of the hip-joint. In the last case the success was less perfect, on account of the operator having been obliged to use a solution of inferior strength, but was fairly satisfactory. Professor J. Williston and other surgeons of eminence have also used the method with complete success.

**Living Encrinites.**—The encrinites are among the most interesting of the animals that inhabit the great sea-depths. They formerly played very important parts among the marine fauna, and their remains are found in great masses in the rocks of all the earlier formations. Their shapes, always graceful, now resembling lilies, now palm-trees, were wonderfully varied during the primary and secondary periods. They were nearly always fixed to the ground, while, in modern seas, the echinoderms most like them, the *Comatulæ*, are free, and have forms resembling star-fish, but lighter and more elegant. Encrinites were regarded as extinct till in the middle of the eighteenth century a naval officer brought to Europe a specimen which had been fished up alive. A few years afterward, Guettard described to the French Academy of Sciences another specimen which, dried, is still preserved in the collection of the Museum of Natural History; and, at a later date, some encrinites from the Antilles were distributed among different museums and collections in Europe. But these animals were rare till the time of the American dredging expeditions under Louis Agassiz. It is now known that encrinites, while they are not so abundant as they were in the epoch when limestone-beds were formed out of them, are by no means rare in the deep seas; and zoölogists are in a position to tell geologists what manner of life they lived, and what was the structure of those organisms whose remains are found everywhere, and whose real character once appeared so hard to determine. The discoveries of Sars, in the northern seas, of Pourtales and Alexander Agassiz in the Antilles, and of the various English expeditions, have raised the number of known species of crinoids to thirty-two, which are divided among four families and six genera.

**Geology at the American Association.**—Professor Orton delivered an opening address in the Geological Section of the American Association, on "Problems in the Study of Coal; with a Sketch of Recent Progress in Geology." The recent discoveries of the pteraspidian type of fishes in the Onondaga group of Central Pennsylvania, and of scales and spines of fishes (*Onchus Clintoni*) in the iron sandstone of the Middle Clinton group of the same region, give to American formations the earliest examples of vertebrate life yet known. A living shark has been identified that proves to be so nearly allied to the *Cladodus* of carboniferous time that it would be doing but little violence to refer it to that genus. Three separate discoveries of Upper Silurian scorpions and a Middle Silurian cockroach carry the life of the earliest land animals a few steps further back than the records of the strata had before disclosed. Two species of pulmoniferous mollusks from the lower part of the carboniferous rocks of Nevada constitute the sole known representatives of that group in palæozoic time. Stratigraphical geology appears to be attaining a somewhat juster recognition than has hitherto prevailed; and the growing use of the microscope in geology is to be noted as one of the directions in which progress is apparent and marked. In the later stages and higher forms of vertebrate life, "American geology holds an easy and undisputed pre-eminence. Along the eastern slopes of the Rocky Mountains there are being disentombed the remnants of great faunas of cretaceous and tertiary time that are quite without parallel in the

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history of geology. While these faunas are remarkable for the great number and variety of the species and individuals, and also for the enormous size of some of their forms, it is in other directions that their highest interest lies. By their anomalous and altogether unexpected characters, by their strange combination and dissociation of peculiarities of structure, they throw a flood of light on the question of evolution, and give us a key to the development of the existing creation that, before their discovery, it was too much to expect we should ever possess." The most important service, Professor Orton further remarked, that has been rendered in the American field, is the recent mapping of the great moraine from the Atlantic border to Dakota. On "the unfinished problems relating to the geology and chemistry of coal," Professor Orton enumerated the four principal theories of the formation of coal-beds, inclining to favor the peat-bog theory of Lesquereux and Brongniart. In accounting for coal-fields—a succession of coal-beds separated by marine formations and inorganic sediments of sandstone and iron-ore—we have to seek an explanation of the regularity of the intervals, and are referred to Croll's theory of an astronomical cause. Various unsettled questions also appear on the chemical side; and, while much has been done, much remains to be done in the field of the microscopical structure of coal. These problems will probably all be solved, but when that is done, "out of these old carboniferous swamps, new questions, larger, deeper than any we now see, will perpetually arise to stimulate by their discovery and to reward by their solution that love of knowledge for its own sake which makes us men." Captain E. L. Corthell presented a paper, which was read at a general meeting, on the contractions of the earth's crust and surplusage in mountain-structure. New discoveries of fossils in the older strata of various regions were announced. Professor Henry S. Williams presented a paper on the comparative stratigraphy of the southern counties of New York and the adjoining counties of Pennsylvania, and Northern Ohio as far as Cleveland. Professor E. W. Claypole discussed the problem of the origin of the palæozoic sediments of Pennsylvania. Professor Lewis E. Hicks described the structure and relation of the Dakota group in Nebraska. Mr. G. K. Gilbert described an old shore-line of Lake Ontario, which he had traced half-way about its basin. Professor A. R. Crandall described some small volcanic dikes which have recently been discovered in Elliot County, Kentucky. Professor Orton described the gas and oil wells of Northwestern Ohio, in the region of which Findlay is the center, and whose sources of supply are in formations lower than any from which gas has been known before to issue. The flow of gas ranges in the various wells from 100,000 to 1,200,000 cubic feet per day. The petroleum is not very abundant, and is black, sulphurous, and of a gravity of about 35°. The formation whence the gas and oil issue is a porous magnesian limestone identified as Trenton. Professor A. C. Worthen described the quaternary deposits of Central and Southern Illinois as observed in cutting coal-mine shafts through them. The bed-rock surface is diversified by valleys much as the drift surface above, but with a different drainage system. At the bottom is a stratified clay, in part gravelly, which appears to be derived from the waste of the bed-rock. Above this is a forest-bed, which, though not a universal feature, is so widely spread as to make much of the well-water unfit for use. Over this lies a blue and yellow gravelly clay, with glaciated bowlders sometimes as large as two feet in diameter; and, finally, a few feet of loess, covered with a thin bed of fine clay.

**Educational Museums.** — Dr. Burt G. Wilder, addressing the Biological Section of the American Association on "Educational Museums of Vertebrates," maintained that every institution, of whatever grade, should have one. In selection quality is more important than quantity, and arrangement is usually more needed than acquisition. As a rule, each specimen should teach but one thing, and that thoroughly. The same form may, therefore, properly recur in several parts of the museum, to illustrate different parts or ideas. True economy consists in paying liberally for what is wanted, rather than in taking what is not wanted as a gift. "In addition to, or in place of, the three great series—

physiological, taxonomic, and geographical—which are commonly attempted in museums, but which it is rarely possible to complete, specimens representing an equal amount of time or money would have a higher educational value if divided among a considerable number of special series, each illustrating some morphological or teleological principle. . . . Instead of vainly attempting to obtain and exhibit all the species of all the groups, most educational museums would attain more satisfactory results by selecting the more interesting or instructive forms from all classes, and limiting their efforts to complete groups for a few, upon which, as well as upon a larger number, may be illustrated the principles of classification and of individual and geographical variation. Among special series other than systematic, are analogous forms and structures which are sometimes mistaken for one another, but are more readily discriminated when brought together. . . . Physiological series would contain the hibernating animals, those which are blind or nearly so, and such as are provided with scent-glands or tusks, and all poisonous vertebrates. A local collection should embrace all the animals of the vicinity, and will benefit the student, both as an example for him to follow or improve upon, and as exemplifying the laws of geographical distribution and the influence of environment. The local collection need not contain anatomical preparations, but should exhibit both sexes and all stages of growth—its mode of life, friends, and foes—so as to interest also the children, farmers, fishermen, hunters, and other residents of the neighborhood."

In a paper on the hybridization and cross-fertilization of plants, Professor E. L. Sturtevant, of the New York Agricultural Experiment Station, showed that in our common vegetables cross-fertilization tends toward atavism, or reversion to an ancestral form, rather than to a blending of the individual properties of the present plants.

In describing some of the habits of the musk-rat, Mr. A. W. Butler mentioned well-authenticated cases of the change of habits as a means of adapting itself to the changed conditions of life brought about by the presence of civilized man.

Mr. J. C. Arthur reported, as the result of his investigations of pear-blight, that sap from an infected tree when inoculated into a healthy tree, invariably produced the disease; that when cultures to the sixth generation of organisms were made with all precaution to prevent error, and healthy trees were inoculated with the pure culture of this sixth generation, the tree was stricken with blight, which started from the point of inoculation and gradually extended over the whole plant; and that, wherever there was a blight not produced by freezing, bacteria of this species were invariably present. Professor Bessey read a paper on the inflorescence of the dodder.

The Section of Histology and Microscopy was discontinued, at the request of its members.

**The Native Tribes of Alaska.**—Mr. W. H. Dall's address to the Anthropological Section of the American Association was on "The Native Tribes of Alaska." Passing by the details in it which are chiefly of interest to specialists, we are informed that the tribal limits of the western Innuit, geographically considered, are very mutable, and constantly changing in small details. This arises from the fact that the geographical group which we have called a tribe among the Innuit is not a political organization headed by a chief or chiefs, but simply a geographical aggregation of people who have by possession obtained certain *de facto* rights of hunting, fishing, etc., over a certain area. The jealousy of adjacent groups keeps the imaginary boundary-line pretty well defined, through fear of reprisals should it be violated, but under the influence of the whites, with their trading-posts, the boundaries are becoming violable with impunity, and are falling into oblivion. Hence the geographical names distinguishing the groups are ceasing to have any serious significance. The degree of civilization which the Aleuts have attained is very promising. The people are not scattered over the archipelago except in their hunting-parties. Notwithstanding the nominal division into groups, they are practically as much one people as those of two adjacent English counties. The Rev. Mr. Dorsey gave an account of the peculiarities of the language spoken at the Siletz Indian

agency, in Oregon, the population of which is made up of a consolidation of more than twenty tribes. The Indians are all more or less civilized, some of them taking newspapers, are very polite to strangers, and in many respects resemble the Ainos. In their language, the verb varies with the position of the object. They can not say "that man," but must say "that man walking," or sitting, or standing, etc. There are three sets of cardinal numbers, human, inhuman, and inanimate. All their villages have local names, as "the people of the ash-trees," "the people by the hill," "the people of the cañon," etc. A man must marry a woman from another village, and his children belong to the village of their father. They will not mention the names of the wild-cat, field-mouse, and some other animals, before their children, lest they bring sickness and death upon them. Five is the mystic number among them.

Miss A. C. Fletcher described the sacred war-tent of the Omahas, in which the sacred and ritual objects are stored. These objects are held in great reverence, and are under a special keeper. Among them is the sacred shell, a large *Unio*, which is contained in several leathern pouches, one within the other, and in which are placed strips of the inner bark of the cedar, and a scalp. In the tent are also the sacred wolf-skin, and two bundles covered with tanned skins. One of the bundles contains bird-skins; the other contains various deadly poisons. There are besides a staff of cedar and one of iron-wood, a small pipe-stem, two war-pipes, tobacco, and a scalp. The sacred shell must never touch the ground, for, if it should, a devouring fire would come from it. If any one but the keeper touches any of the objects, he will be afflicted with grievous sores, but the evil may be averted by going through certain ritual ablutions. All of these objects have been given, with the consent of the chiefs, to the Peabody Museum of Archæology.

**The "Flight" of Flying-Fish.**—The debate goes on as to whether flying-fish actually fly or only appear to fly, under an impulse which they have received while still in the water. One of the most authoritative opinions that has been expressed on the subject is probably that of Professor Möbius, of Kiel, who declares that "flying-fish are incapable of flying, for the simple reason that the muscles of their pectoral fins are not large enough to bear the weight of their body aloft in the air." The average weight of the muscles doing this work in birds is one sixth that of the whole body, and that of bats one thirteenth, while that of flying-fishes is only one thirty-second. The impulse to the propulsion of the flying-fish is delivered while they are still in the water, by the powerful masses of muscles on both sides of their body, which are of much greater breadth than in the case of the herring or any other fish of their own size. The visible flickering of the fins is only a vibration akin to the flapping of a sail.

## NOTES.

An extensive copper region is known to exist in Texas, running westward of Red River, from the line of the Indian Territory through several counties. The Grand Belt mines, fifty miles from Harrold, in Wilberger County, are operated by a company which owns claims for sixty-five miles along the ore-belt, and along which about sixty openings have been made, of an average depth of seven or eight feet. The ore is found principally in shallow pockets, and at the main point of taking out is said to average about fifty-four or fifty-five per cent of metallic copper.

In section A of the American Association, Professor Newton read a paper on "The Effect of Small Bodies passing near a Planet upon the Planet's Velocity"; Professor Harkness, of the U. S. Naval Observatory, on the flexure of transit instruments; Professor Hough, of the Dearborn Observatory, Chicago, presented a description of some improvements recently introduced in the printing chronograph devised by him. Professor J. Burkitt Webb described a new method of using polar co-ordinates; Mr. C. H. Rockwell, of Tarrytown, New York, presented some results of his observations for time and latitude, with a new instrument called the *almucantar*, which promises to be a very valuable addition to scientific apparatus.

M. Guillemin has formed a number of alloys of cobalt and copper. They are all red, have a fine fracture, and are much more tenacious than copper—even as high as from fifty to one hundred per cent more so, according to the proportion of cobalt. Five per cent of cobalt is enough to give an alloy of great resistance.

In the Geological Section of the British Association, Mr. H. Johnston Lavis presented the report of the committee for the investigation of the volcanic phenomena of Vesuvius. Its work had been interfered with by various circumstances growing out of the prevalence of cholera in Naples, but a careful record had been kept of daily observations of the variations in the activity of the volcano, and photographs had been taken of all important changes of the crater-plane and in the cone of eruption.

After a very interesting vice-presidential address on the phosphorescence of marine animals, Dr. W. B. Carpenter remarked, in the Biological Section of the British Association, that disciples of evolution were straining points to make it appear that the luminosity was of particular use and was propagated and increased by natural selection. He thought it was a great pity to strain that argument too far. It would be much better to abstain from more than mere speculation in regard to the use of this remarkable endowment.

Professor J. G. McKendrick described at Aberdeen some experiments he had made in the exposure of microphytes contained in meat to extremely low temperatures. The results showed that we might take organic fluids and expose them to the temperature of 120° below zero Fahrenheit for at least a hundred hours, and that then, after they had been placed in a higher temperature, fermentation and putrefaction would go on in the ordinary way. These facts destroyed any hope of a practical result being obtained from sterilization by cold.

Dr. B. Croumbie Brown reported in the Geographical Section of the British Association concerning his visit to the Forest School of Spain, one of the objects of which school was to insure that not a drop of water found its way to the sea without doing its best for the country. Spain was now convinced of the importance of scientific forestry, and of the function of forests in affecting the distribution and quantity of the rainfall, and was doing its best to conserve and replenish them.

The Emperor of Russia has conferred the golden honorary medal of the Empire upon Messrs. Alvan Clark & Sons, of Cambridge, Massachusetts, in acknowledgment of the excellent performances of the great object-glass furnished by them for the observatory at Pulkowa. This is the second award of the medal that has been made by the present emperor.

## OBITUARY NOTES.

The death is announced of M. Breton des Champs, a French mathematician and scientific writer, who was best known from the part he took, a few years ago, in exposing the forgery of the letter alleged to be by Sir Isaac Newton which was sold to M. Chasles.

The death is announced of M. Edmond Boissier, an eminent French botanist. His career in science began in 1837, when he traveled in Spain, in preparation for his work on the botany of that country, which was published from 1839 to 1845. He afterward botanically explored various parts of Southeastern Europe and Asia Minor. His great work was the "Flora Orientalis," which was published from 1867 to 1881. He was engaged upon the supplements to this book at the time of his death. He was also author of a number of smaller works and monographs, among which was a series on the *Euphorbiæ*.

Walter Weldon, a distinguished English chemist, died September 21st, in the fifty-third year of his age. He was the inventor of the "Weldon process" for the regeneration of the manganese peroxide used in the generation of chlorine, by the aid of which the production of bleaching-powders has been vastly facilitated, with a great saving of expense in manufacturing processes. For this he received the grand medal of the French Société d'Encouragement, in presenting which Professor Dumas congratulated him on "having cheapened every sheet of paper and every yard of calico made in the world." He was engaged at the time of his illness in studying processes for producing hydrochloric acid from calcium chloride.

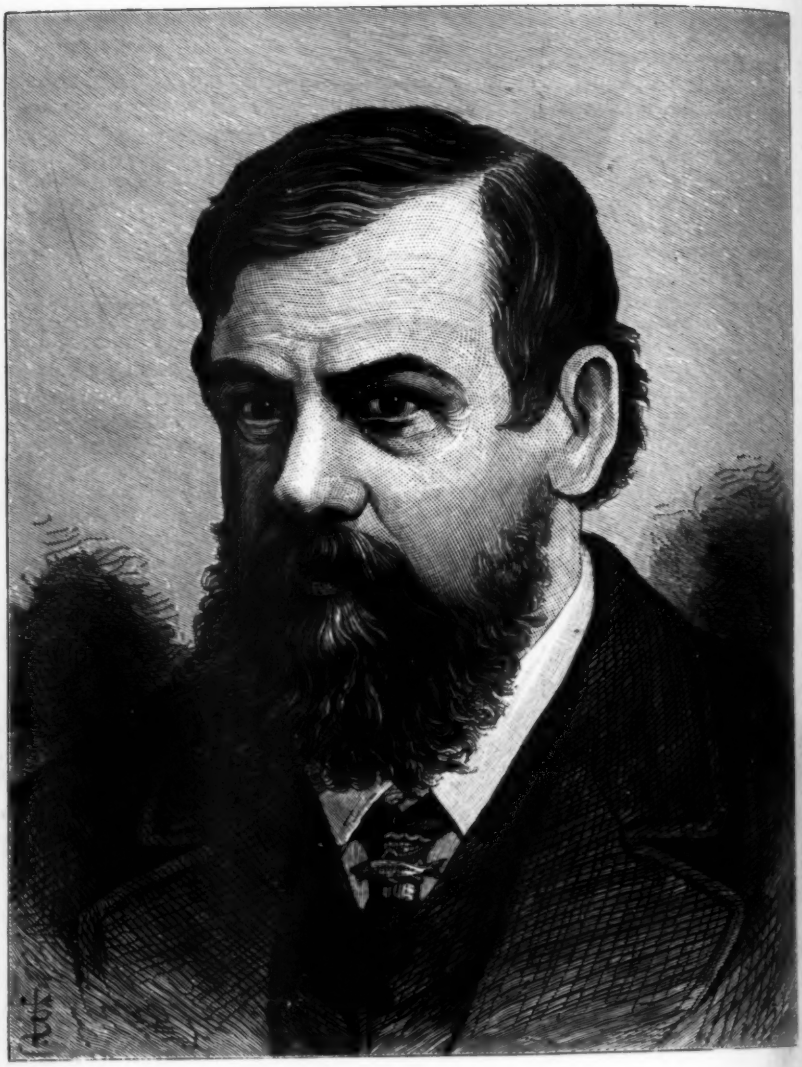
Mr. John Muirhead, the inventor of the Muirhead galvanic battery, which has served as a model for most of the existing batteries, has recently died, at the age of seventy-eight years.

Dr. H. W. Reichardt, Professor of Botany in the University of Vienna, died by suicide in August last, in the fiftieth year of his age. He contributed many articles on botany to the scientific journals of his country, chiefly to the "Journal of the Vienna Academy of Sciences." His last undertaking, a catalogue of the Imperial Botanical Cabinet, of which he was keeper, remains unfinished.

Dr. Albert Fitz, who has published some noteworthy researches in fermentation, died at Strasburg on the 11th of May.

Dr. Karl Julius Andrae, Professor of Mineralogy and Paleontology in the University of Bonn, died May 8th, in his sixty-ninth year.

Ludwig Freiherr von Hohenbühl, or Heufler von Rosen, an Austrian botanist, whose specialty was the cryptogams, died on the 9th of June, sixty-seven years old.



FRANCIS TREVELYAN BUCKLAND.